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FINAL FOCUSED FEASIBILITY STUDY FOR INTERIM REMEDIAL ACTION AT OPERABLE UNIT 4 (OU 4) WITH TRANSMITTAL LETTER NTC ORLANDO FL
5/23/1997
ABB ENVIRONMENTAL

ABB

May 23, 1997

8545.330

Commanding Officer
SOUTHNAVFACENGCOM
2155 Eagle Drive
N. Charleston, S.C. 29419-9010

Attn: **Ms. Barbara Nwokike, Code 187300**

Subject: NTC, Orlando Operable Unit 4 (OU4)
Interim Remedial Action (IRA)
Final Focused Feasibility Study
Contract; N62467-89-D-0317/CTO 107

Dear Barbara:

Enclosed for your use is the Final Focused Feasibility Study (FFS) for the IRA at OU4. Comments received from the U.S. Environmental Protection Agency and Florida Department of Environmental Protection have been included. These comments have not changed the intent of the original draft document.

Should you have any questions or need additional information, please call Shannon Gleason at (703) 769-8181 or me at (407) 895-8845.

Very Truly Yours,
ABB ENVIRONMENTAL SERVICES, INC.

John Kaiser

John P. Kaiser
Installation Manager
Enc.

JK/cp
cc: W. Hansel (SDIV)
M Maughon (SDIV)
J. Mitchell (FDEP)
N. Rodriguez (EPA)
Lt. G. Whipple (NTC, ORL)
M. Salvetti (ABB-ES)
B. Cohose (Bechtel)
S. McCoy (Brown & Root)

ABB Environmental Services Inc.

1080 Woodcock Road, Suite 100
St. Paul Building
Orlando, Florida 32803

Telephone (407) 895-8845
Fax (407) 896-6150

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FOCUSED FEASIBILITY STUDY
OPERABLE UNIT 4

NAVAL TRAINING CENTER
ORLANDO, FLORIDA

UNIT IDENTIFICATION CODE: N65928
CONTRACT NO.: N62467-89-D-0317/107

MAY 1997

SOUTHERN DIVISION
NAVAL FACILITIES ENGINEERING COMMAND
NORTH CHARLESTON, SOUTH CAROLINA
29419-9010

FOCUSED FEASIBILITY STUDY
OPERABLE UNIT 4

NAVAL TRAINING CENTER
ORLANDO, FLORIDA

Unit Identification Code: N65928

Contract No.: N62467-89-D-0317/107

Prepared by:

ABB Environmental Services, Inc.
2590 Executive Center Circle, East
Tallahassee, Florida 32301

Prepared for:

Department of the Navy, Southern Division
Naval Facilities Engineering Command
2155 Eagle Drive
North Charleston, South Carolina 29418

Barbara Nwokike, Code 1873, Engineer-in-Charge

May 1997

CERTIFICATION OF TECHNICAL
DATA CONFORMITY (MAY 1987)

The Contractor, ABB Environmental Services, Inc., hereby certifies that, to the best of its knowledge and belief, the technical data delivered herewith under Contract No. N62467-89-D-0317/107 are complete and accurate and comply with all requirements of this contract.

DATE: May 19, 1997

NAME AND TITLE OF CERTIFYING OFFICIAL: John P. Kaiser
Task Order Manager

NAME AND TITLE OF CERTIFYING OFFICIAL: Mark Salvetti, P.E.
Project Technical Lead

(DFAR 252.227-7036)

The engineering evaluations and professional opinions rendered in this planning document that describes the Focused Feasibility Study, Operable Unit 4, Naval Training Center, Orlando, Florida, were conducted or developed in accordance with commonly accepted procedures consistent with applicable standards of practice. This document is not intended to be used for construction of the selected alternative.

Willard A. Murray

5/20/97

Willard A. Murray, Ph.D.
Professional Engineer No. PE-0039866
Expires February 28, 1999

FOREWORD

To meet its mission objectives, the U.S. Navy performs a variety of operations, some requiring the use, handling, storage, or disposal of hazardous materials. Through accidental spills and leaks and conventional methods of past disposal, hazardous materials may have entered the environment in ways unacceptable by today's standards. With growing knowledge of the long-term effects of hazardous materials on the environment, the Department of Defense (DOD) initiated various programs to investigate and remediate conditions related to suspected past releases of hazardous materials at their facilities.

One of these programs is the Base Realignment and Closure (BRAC) Cleanup Program. This program complies with the Base Closure and Realignment Act of 1988 (Public Law (P.L.) 100-526, 102 Statute 2623) and the Defense Base Closure and Realignment Act of 1990 (P.L. 101-510, 104 Statute 1808), which require the DOD to observe pertinent environmental legal provisions of the Comprehensive Environmental Response, Compensation, and Liability Act (CERCLA); the 1992 Community Environmental Response Facilitation Act; Executive Order 12580; and the statutory provisions of the Defense Environmental Restoration Program, the National Environmental Policy Act (NEPA), and any other applicable statutes that protect natural and cultural resources.

CERCLA requirements, in conjunction with corrective action requirements under Subtitle C of the Resource Conservation and Recovery Act (RCRA), govern most environmental restoration activities. Requirements under Subtitles C, D, and I, of RCRA, as well as the Toxic Substances Control Act, the Clean Water Act, the Clean Air Act, the Safe Drinking Water Act, and other statutes, govern most environmental mission or operational-related and closure-related compliance activities. These compliance laws may also be applicable or relevant and appropriate requirements for selecting and implementing remedial actions under CERCLA. NEPA requirements govern the Environmental Impact Analysis and Environmental Impact Statement preparation for the disposal and reuse of BRAC installations.

The BRAC program centers on a single goal: expediting and improving environmental response actions to facilitate the disposal and reuse of a BRAC installation, while protecting human health and the environment.

The Southern Division, Naval Facilities Engineering Command (SOUTHNAVFACENGCOM); the U.S. Environmental Protection Agency; and the Florida Department of Environmental Protection collectively coordinate the cleanup activities through the BRAC cleanup team. This team approach is intended to foster partnering, accelerate the environmental cleanup process, and expedite timely, cost-effective, and environmentally responsible disposal and reuse decisions.

Questions regarding the BRAC program at Naval Training Center, Orlando should be addressed to the SOUTHNAVFACENGCOM BRAC Environmental Coordinator, Mr. Wayne Hansel, Code 18B7, at (407) 646-5294 or SOUTHNAVFACENGCOM Engineer-in-Charge, Ms. Barbara Nwokike, Code 1873, at (803) 820-5566.

EXECUTIVE SUMMARY

ABB Environmental Services, Inc., under contract to Southern Division, Naval Facilities Engineering Command (SOUTHNAVFACENGCOM), has prepared this Focused Feasibility Study (FFS) for the Interim Remedial Action (IRA) at Operable Unit (OU) 4, Former Dry-Cleaning and Laundry Facility, at the Naval Training Center (NTC), Area "C", in Orlando, Florida. The approach to the IRA at OU 4, a chlorinated solvent-contaminated site, was developed in conjunction with the Orlando Partnering Team (OPT), which includes representatives from the Florida Department of Environmental Protection, the U.S. Environmental Protection Agency Region IV, SOUTHNAVFACENGCOM and their consultants, and the NTC, Orlando Public Works Department.

The purpose of this FFS is to identify remedial action objectives (RAOs), identify remedial action alternatives that will achieve those objectives, and evaluate the alternatives to provide the basis for selection of a preferred remedial alternative for the IRA.

The OU 4 IRA was discussed at the November and December 1996 OPT meetings and an evaluation of conditions and viable alternatives for the IRA was completed. Based on this evaluation, it was determined that the focus of the IRA would be to gain control over the migration of contaminated groundwater discharging to Lake Druid, thereby addressing a source of sediment and surface water contamination. Conditions in Lake Druid would be monitored (i.e., surface water and sediment sampling and analysis) during an IRA for groundwater, and these data would be evaluated in the Remedial Investigation and Feasibility Study (RI/FS) for the site. At any time, an additional IRA for sediment or surface water could be implemented.

One RAO was developed for this FFS:

- To gain control over the migration pathways of volatile organic compound (VOC) concentrations that contribute to surface water exceedances in Lake Druid.

Potential remedial technologies and alternatives presented in this FFS were developed for the IRA. In this manner, each technology discussed in this FFS achieves the defined RAO, is effective, and is easy to implement (i.e., no pilot- or bench-scale studies are necessary). Because site characterization has not been fully completed at OU 4 (i.e., the overall RI/FS is yet to be completed), treatment alternatives were developed using a streamlined process. Evaluation of complex or innovative technologies generally requires a more complete site characterization than is available at this stage. Therefore, evaluation of these complex or innovative technologies is deferred to the overall RI/FS.

Three groundwater remedial alternatives were developed for the OU 4 IRA:

- groundwater extraction and treatment (via air stripping) with discharge to the Orlando sewage treatment plant,

- *in situ* treatment via air sparging, and

- groundwater interception with a recirculation well and *in situ* treatment via in-well air stripping.

The recommended alternative for the OU 4 IRA is *in situ* treatment via recirculation/in-well air stripping. This alternative would gain control over the migration pathways of VOC concentrations that contribute to surface water exceedances in Lake Druid. This alternative will also be effective in treating VOCs in groundwater to required treatment levels and is relatively easy to implement. The evaluation of this alternative was completed based on seven of the nine criteria established in the National Oil and Hazardous Substances Pollution Contingency Plan. The eighth and ninth criteria, State and public acceptance, will be addressed for the OU once review comments on the FS are received from the State and once a presentation of the FFS has been made to the NTC, Orlando Restoration Advisory Board.

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Operable Unit 4
Naval Training Center
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GLOSSARY

ABB-ES	ABB Environmental Services, Inc.
ARAR	Applicable or Relevant and Appropriate Requirement
atm-m^3/mole	atmosphere-cubic meter per mole
bls	below land surface
°C	degrees Celsius
CERCLA	Comprehensive Environmental Response, Compensation, and Liability
cis-DCE	cis-1,2-dichloroethene
COC	chemical of concern
DCE	1,1-dichloroethene
DRMO	Defense Reutilization and Marketing Office
EBS	Environmental Baseline Survey
FAC	Florida Administrative Code
FDEP	Florida Department of Environmental Protection
FFI	Focused Field Investigation
FFS	Focused Feasibility Study
FS	Feasibility Study
FSWQS	Florida Surface Water Quality Standards
ft/day	feet per day
ft^2/day	square feet per day
ft/ft	feet per foot
GAC	granular activated carbon
GC	gas chromatograph
g/mℓ	grams per milliliter
gpd	gallons per day
gpd/ft	gallons per day per foot
gpm	gallons per minute
H	Henry's law constant
H_2O_2	hydrogen peroxide
H_g	mercury
HOCl	hypochlorous acid
ID	inside diameter
IRA	Interim Remedial Action
IR	Installation Restoration
K_{ow}	octanol-water partition coefficient
K_{oc}	soil-sediment partition coefficient
lb/ft^3	pounds per cubic foot
lb/yr	pounds per year
MCL	maximum contaminant level
mg/ℓ	milligrams per liter
mm	millimeter

$\mu g/kg$	micrograms per kilogram
$\mu g/\ell$	micrograms per liter
NCP	National Oil Hazardous Substances Pollution Contingency Plan
NPDES	National Pollutant Discharge Elimination System
NPL	National Priorities List
NTC	Naval Training Center
O&M	operation and maintenance
OPT	Orlando Partnering Team
OU	Operable Unit
PAC	powdered activated carbon
PCE	tetrachloroethene
POTW	publicly owned treatment works
PRE	Preliminary Risk Evaluation
PVC	polyvinyl chloride
RAM	Responsibility Assignment Matrix
RAO	remedial action objective
RBC	rotating biological contactor
RI	Remedial Investigation
RI/FS	Remedial Investigation and Feasibility Study
SA	site assessment
SCM	site conceptual model
SOUTHNAV-FACENGCOM	Southern Division, Naval Facilities Engineering Command
STP	Sewage Treatment Plant
SVE	soil vapor extraction
SVOC	semivolatile organic compound
SW/SD	surface water and sediment
TBC	to be considered
TCE	trichloroethene
TCL	target compound list
THM	trihalomethanes
TOC	total organic carbon
TSS	total suspended solids
USEPA	U.S. Environmental Protection Agency
UV/OX	ultraviolet radiation with oxidation
VC	vinyl chloride
VOC	volatile organic compound

1.0 INTRODUCTION

ABB Environmental Services, Inc. (ABB-ES), under contract to Southern Division, Naval Facilities Engineering Command (SOUTHNAVFACENGCOM), has prepared this Focused Feasibility Study (FFS) for the Interim Remedial Action (IRA) at Operable Unit (OU) 4, Former Dry Cleaning and Laundry Facility, at the Naval Training Center (NTC), Area C, in Orlando, Florida. The FFS is being conducted under contract number N62467-89-D-0317-107. This report presents the results of the FFS for OU 4 that includes the development, screening, and evaluation of potential remedial alternatives for the IRA.

The approach to the IRA at OU 4 was developed in conjunction with the Orlando Partnering Team (OPT), which includes representatives from the Florida Department of Environmental Protection (FDEP), the U.S. Environmental Protection Agency (USEPA) Region IV, SOUTHNAVFACENGCOM and their consultants, and the NTC, Orlando Public Works Department. The remedial alternative recommended in this FFS for the OU 4 IRA is considered interim in nature; a final remedial alternative for the entire OU will be evaluated in the overall Remedial Investigation/Feasibility Study (RI/FS) for OU 4. It is possible that the ultimate remedy for OU 4 may be different from the selected alternative in this FFS, or, alternatively, the selected alternative may become a part of the final solution for the OU.

Potential remedial technologies and alternatives presented in this FFS were developed for the IRA. In this manner, each technology discussed in this FFS achieves the defined remedial action objective(s) (RAOs), is effective, and is easy to implement (i.e., no pilot- or bench-scale studies are necessary).

The following subsections describe site conditions, historical background, and treatability evaluation, and provide a conceptual model for the site.

1.1 OU 4, SITE DESCRIPTION AND HISTORY. OU 4 is located at Area C, which occupies 46 acres and is located approximately 1 mile west of Main Base, off Maguire Boulevard. Area C serves as a supply center for NTC, Orlando and includes a laundry and dry-cleaning facility, which is now closed, and the Defense Reutilization and Marketing Office (DRMO). It is surrounded by urban development, including single- and multifamily residential developments to the north and south, Lake Druid to the west, and an office park to the east. There are no industrial facilities adjacent to Area C.

OU 4 is composed of Study Areas (SA) 12, 13, and 14, as referred in the Draft Site Screening Report, Groups I and II Study Areas (ABB-ES, 1995a) (Figure 1-1). The IRA for OU 4 was focused on approximately 6 acres of SA 13, including the eastern shore area of Lake Druid. Four of these acres are densely vegetated with large trees and heavy undergrowth. The remaining 2 acres are classified as Palustrine wetland by the U.S. Department of the Interior, Fish and Wildlife Service (ABB-ES, 1996a). There is an approximate 10-foot elevation difference between the laundry and Lake Druid.

SA 13 is located in the northwest corner of Area C at Port Hueneme Avenue and Davisville Street, and includes the NTC, Orlando laundry and dry-cleaning facility (Building 1100) and the former location of a boiler house (Building 1101). Building 1101 was located east of Building 1100 and was demolished at

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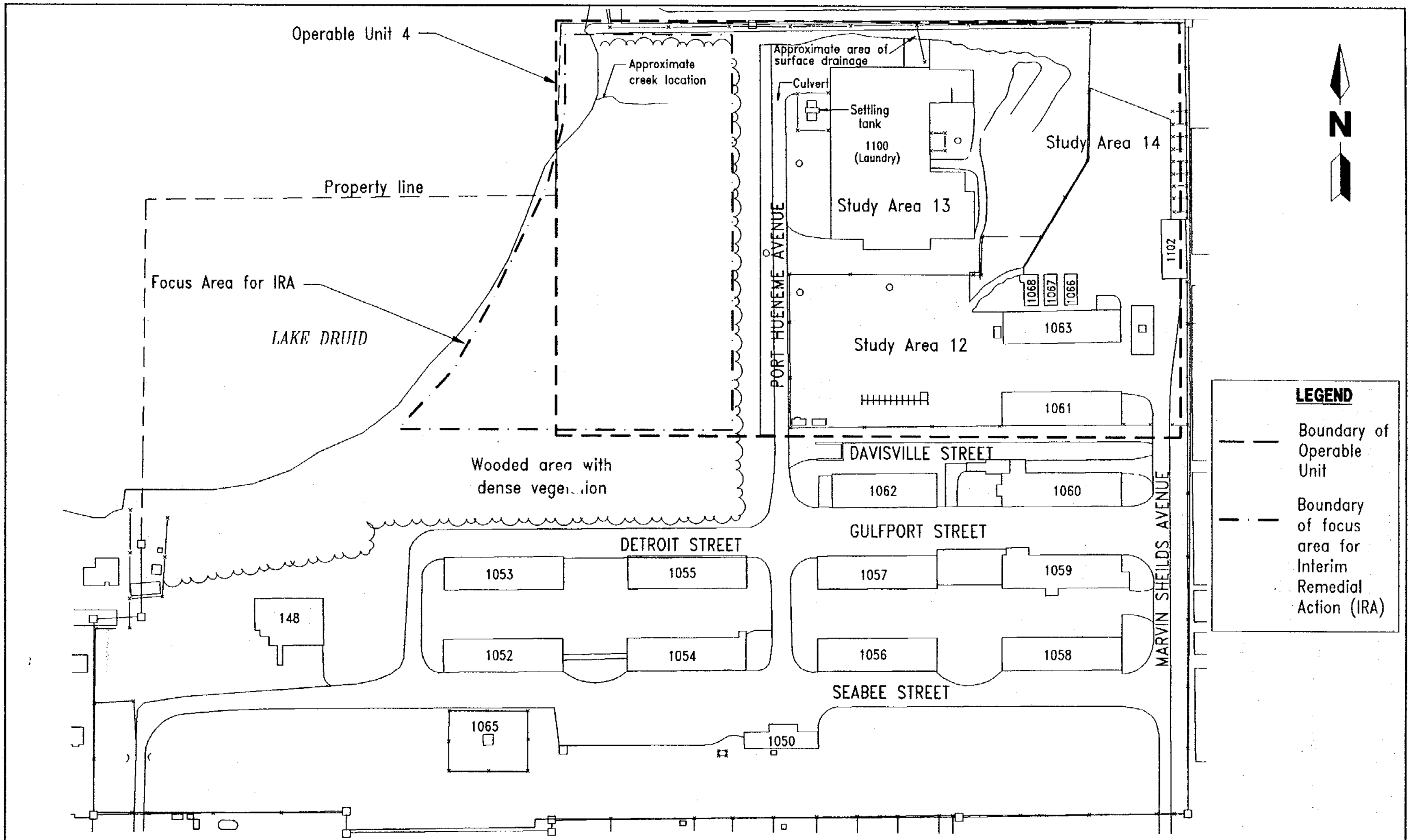

0 125 250
SCALE: 1 INCH = 250 FEET

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FIGURE 1-1
MAP OF AREA C

SOUTHERN DIVISION NAVAL FACILITIES ENGINEERING COMMAND

FOCUSED FEASIBILITY STUDY
OPERABLE UNIT 4

NAVAL TRAINING CENTER
ORLANDO, FLORIDA

some time after 1962. Building 1100 was constructed in 1943 and is a single-story wood-framed structure that has traditionally been used as an industrial laundry and dry-cleaning facility, serving the entire military base. The surrounding property is paved asphalt, except for small areas east and west of the building that are landscaped and grass covered. The paved areas around the perimeter of the building include roads and parking lots. Prior to construction of the facility in 1943, the land was undeveloped. The laundry was closed in the fall of 1994.

Reportedly, hazardous waste materials generated and used in the dry-cleaning process have been poorly managed. At the time of the Environmental Baseline Survey (EBS) (ABB-ES, 1994), there were reportedly many containers in the building, ranging in volume from ½ to 55 gallons, that were open and not labeled. The facility received a Notice of Violation and a citation from the FDEP for unlabeled and unmanifested waste.

Additionally, wastewater from the laundry machines discharged to the sanitary sewer through badly deteriorated drainage trenches in the floor. The floor trenches discharged to a single pipe connected to a settling and surge tank. Due to the volume of water discharged by the laundry machines, a 30,000-gallon surge tank was installed in the mid-1960s. Sludge was removed from this tank annually and disposed of by the DRMO. Waste filters from the dry-cleaning machines were also generated at the facility. Tetrachloroethene (PCE) was separated from the water and filters by heating the assemblies in a pressure cooker. The filters were also disposed of through the DRMO, and the solvent was recycled. In the past, the filters were allegedly disposed of in the North Grinder Landfill (ABB-ES, 1996a). Additionally, discharges of water contaminated with chlorinated solvents reportedly occurred on the property, including direct discharges to Lake Druid.

Building 1100 at Area C was identified in the EBS (ABB-ES, 1994) as a site where releases of hazardous materials have occurred and was designated SA 13; subsequently, it was placed into Group II for site screening activities. The screening investigation was performed in the spring of 1995 and was summarized in the *Site Screening Report, Groups I and II, Operable Unit 4* (ABB-ES, 1995a). Site screening activities included a geophysical survey, soil gas survey, surface and subsurface soil sampling, and the installation of 16 groundwater monitoring wells at SAs 12, 13, and 14.

PCE (up to 680 micrograms per liter [$\mu g/\ell$]) and trichloroethylene (TCE) (up to 52 $\mu g/\ell$) were detected in shallow groundwater samples during site screening at concentrations exceeding FDEP primary drinking water standards. Field gas chromatograph (GC) screening of saturated soil samples collected from the surficial aquifer detected PCE and TCE at concentrations up to 3,770 micrograms per kilogram ($\mu g/kg$) and 1,290 $\mu g/kg$, respectively. Water-level data indicated that the contaminants were likely migrating toward Lake Druid.

The 4 acres of dense vegetation and wetland, including the eastern shore of Lake Druid, were not included in the original site screening investigation.

The results of site screening activities were reviewed in the November 1995 OPT meeting. As a result, the OPT requested that surface water and sediment samples be collected from the lake and groundwater samples be collected between Building 1100 and the lake.

On November 29, 1995, surface water and sediment samples were collected along the shoreline of Lake Druid. PCE, TCE, cis-1,2-dichloroethylene (cis-DCE), 1,1-dichloroethylene (DCE), and vinyl chloride (VC) were detected in both surface water and sediment. At some surface water locations, TCE and cis-DCE were detected at higher concentrations than in groundwater samples collected from monitoring wells during site screening activities. The concentration of TCE detected in surface water exceeded its respective Florida surface water standard, while the concentrations of PCE and DCE did not; no standards are available for cis-DCE and VC.

On December 11, 1995, additional surface water and sediment samples were collected from locations in Lake Druid, further offshore than the November locations. Cis-DCE and TCE were detected in these surface water samples, and TCE and PCE were detected in sediment samples from two locations. Concentrations of chlorinated solvents in these samples were generally detected at concentrations less than those detected nearer the shoreline of Lake Druid.

During the week of December 18, 1995, groundwater samples were collected from the area between Lake Druid and Building 1100 for further screening. Samples were collected from temporary wells installed by hand auger in the heavily vegetated areas and from TerraProbe℠ borings placed in open areas. Sample points were placed along north-south lines adjacent to Building 1100 as well as along the northern fenceline. Samples were collected from three depth intervals at each TerraProbe℠ boring: at the water table, at approximately 18 feet below land surface (bls), and at 30 feet bls. Samples collected from all temporary wells were screened onsite with a portable GC, and were sent offsite for additional laboratory analysis. The results of this investigation indicated that PCE, TCE, and cis-DCE were present in groundwater at elevated concentrations, up to 30 feet bls.

Based on the results of these site screening exercises, and as directed by SOUTHNAVFACENGCOM and the OPT, ABB-ES prepared a workplan for an IRA at OU 4 (ABB-ES, 1996a) to mitigate chlorinated solvent contamination of the lake. The purpose of this workplan was to outline activities to be conducted in support of the IRA (e.g., the focused field investigation [FFI] and the FFS). The goal of the FFI was to define the mechanism and the source of contamination within the lake. A flowchart (Figure 1-2) was presented in this workplan that provided the logic for decision making for various stages or actions to be implemented for the IRA.

The IRA FFI began May 2, 1996. The investigation included (1) defining the extent of contamination in surface water and sediment in Lake Druid, (2) evaluating the source of volatile organics in Lake Druid, (3) delineating the horizontal and vertical extent of volatile organic compound (VOC) contaminants in the groundwater along the lakeshore, (4) collecting information on physical characteristics of the lake, and (5) supporting a focused IRA to mitigate VOCs in Lake Druid.

The FFI results indicated that chlorinated organics are present in groundwater at OU 4 extending from Building 1100 to Lake Druid. The northern extent of the groundwater plume is approximately 50 feet south of the north property line, and the southern extent reaches approximately 300 feet south of the north property line (Figure 1-3). A drive point vertical potential survey that was conducted

8545-73 FIG 1-2 FINAL 050997MAW

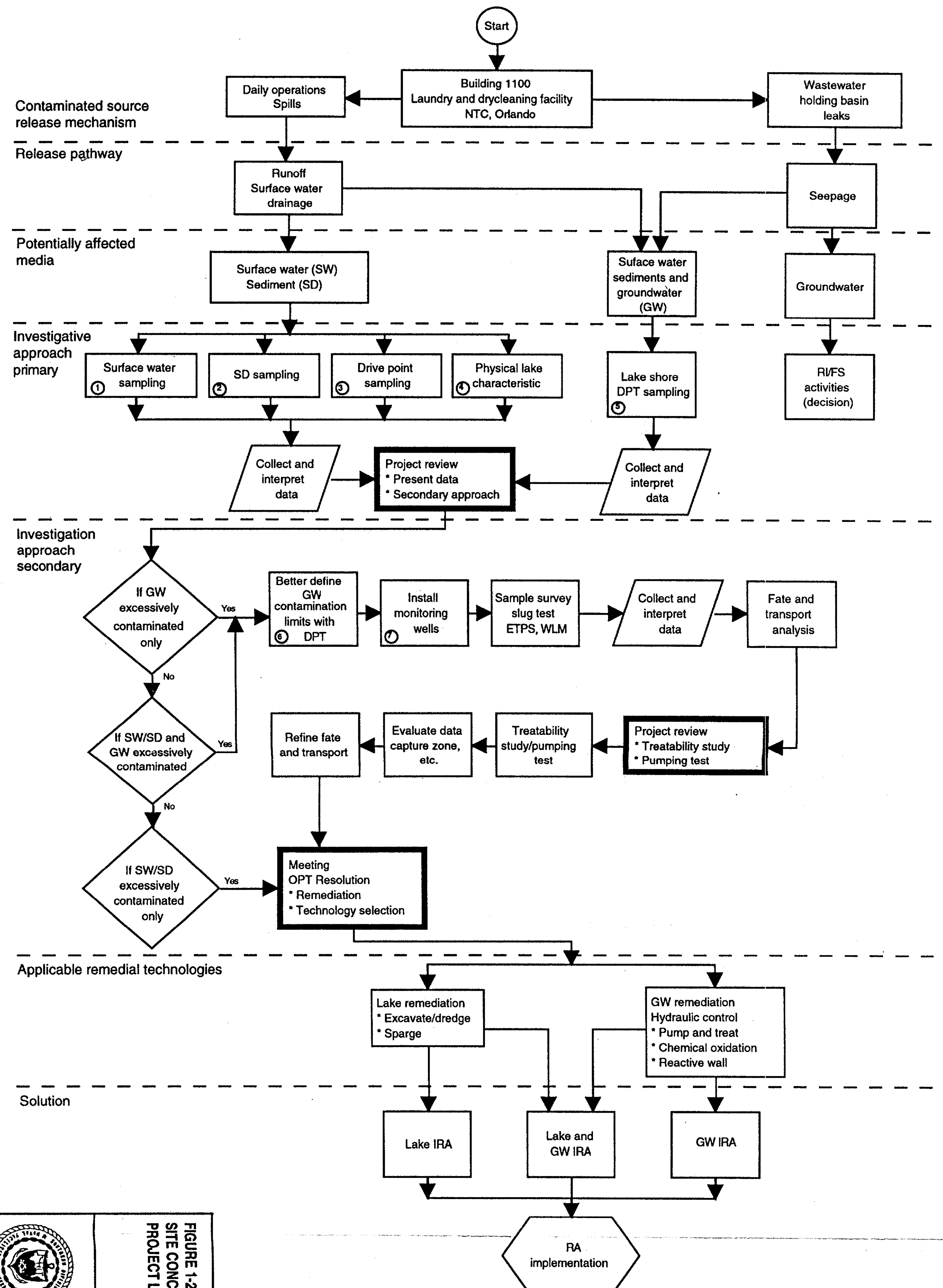

FIGURE 1-2
SITE CONCEPTUAL MODEL:
PROJECT LOGIC DIAGRAM

FOCUSED FEASIBILITY STUDY
OPERABLE UNIT 4
NAVAL TRAINING CENTER
ORLANDO, FLORIDA

NOTES:
- Additional meetings will be scheduled as needed
- Refer to workplan text and figures for definition of Tasks 1 through 7

NTC = Naval Training Center
RI/FS = remedial investigation/feasibility study
DPT = direct-push technology
ETPs = engineering treatability parameters
WLM = water-level measurement
IRA = initial remedial action
RA = remedial action
OPT = Orlando partnering team

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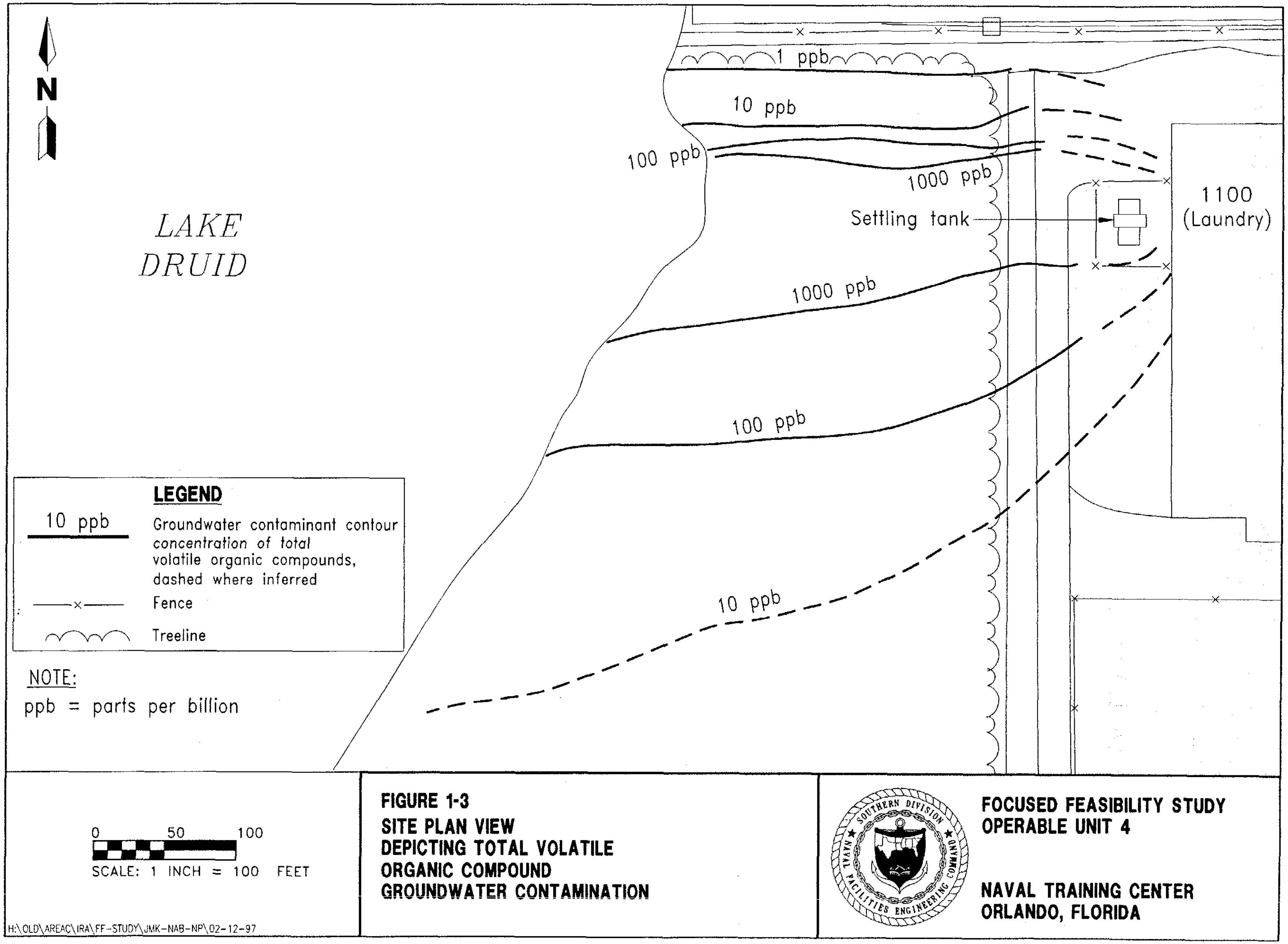

FIGURE 1-3
SITE PLAN VIEW DEPICTING TOTAL VOLATILE ORGANIC COMPOUND GROUNDWATER CONTAMINATION

FOCUSED FEASIBILITY STUDY
OPERABLE UNIT 4

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as a part of the FFI concluded that the groundwater flows into the lake along the lakeshore. Greater detail of the results from the field investigation are provided in the *Interim Remedial Action, Focused Field Investigation Report, Operable Unit 4* (ABB-ES, 1996b).

1.2 TREATABILITY EVALUATION. Following the decision-making process outlined in the flowchart on Figure 1-2, and in conjunction with the OPT, a treatability evaluation, which included a pumping test, preliminary assessment of biological conditions, and an estimate of contaminant mass flux within different media, was conducted from August 1996 through October 1996 to aid in remedial alternative selection for the IRA.

1.2.1 Pumping Test The pumping test was implemented to obtain information regarding the hydrogeologic characteristics of the affected surficial aquifer. Characterization data were used to evaluate alternatives for groundwater remediation in the IRA.

The objective of this pumping test was to collect site-specific data from the surficial aquifer, as follows:

- hydraulic head response within the aquifer due to pumping stress,
- hydraulic conductivity and transmissivity estimates,
- water quality (treatability parameters and contaminants),
- well performance characteristics (e.g., well yield, specific capacity, and operational variance), and
- potential influence of hydraulic control over the affected aquifer.

The pumping test was conducted by pumping one recovery well (RW-1) and monitoring an array of observation wells at various depths and distances from the recovery well.

Analysis of the pumping test data indicated that the recovery well provided good horizontal and vertical connection throughout the surficial aquifer. Results of the pumping test indicated the following:

- hydraulic conductivity of 32.7 feet per day (ft/day);
- transmissivity of 1,960 square feet per day (ft^2/day);
- specific capacity of approximately 9 gallons per minute (gpm) per foot of drawdown;
- at 40 gpm, a capture zone width adjacent to the recovery well perpendicular to the natural groundwater gradient of 115 feet (Figures 1-4 and 1-5 with supporting calculations included in Appendix A) ;

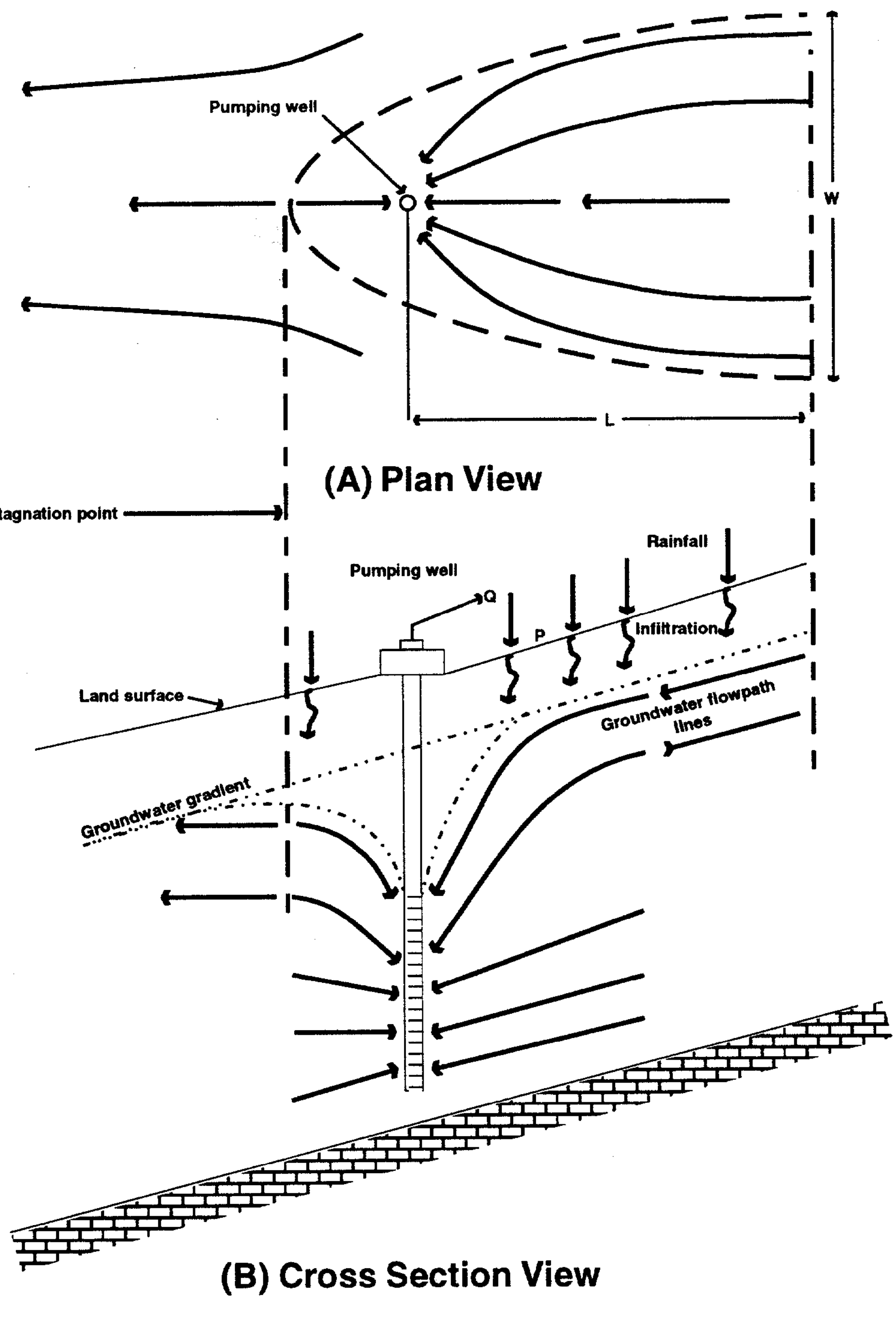

FIGURE 1-4
CONCEPTUAL CAPTURE ZONE

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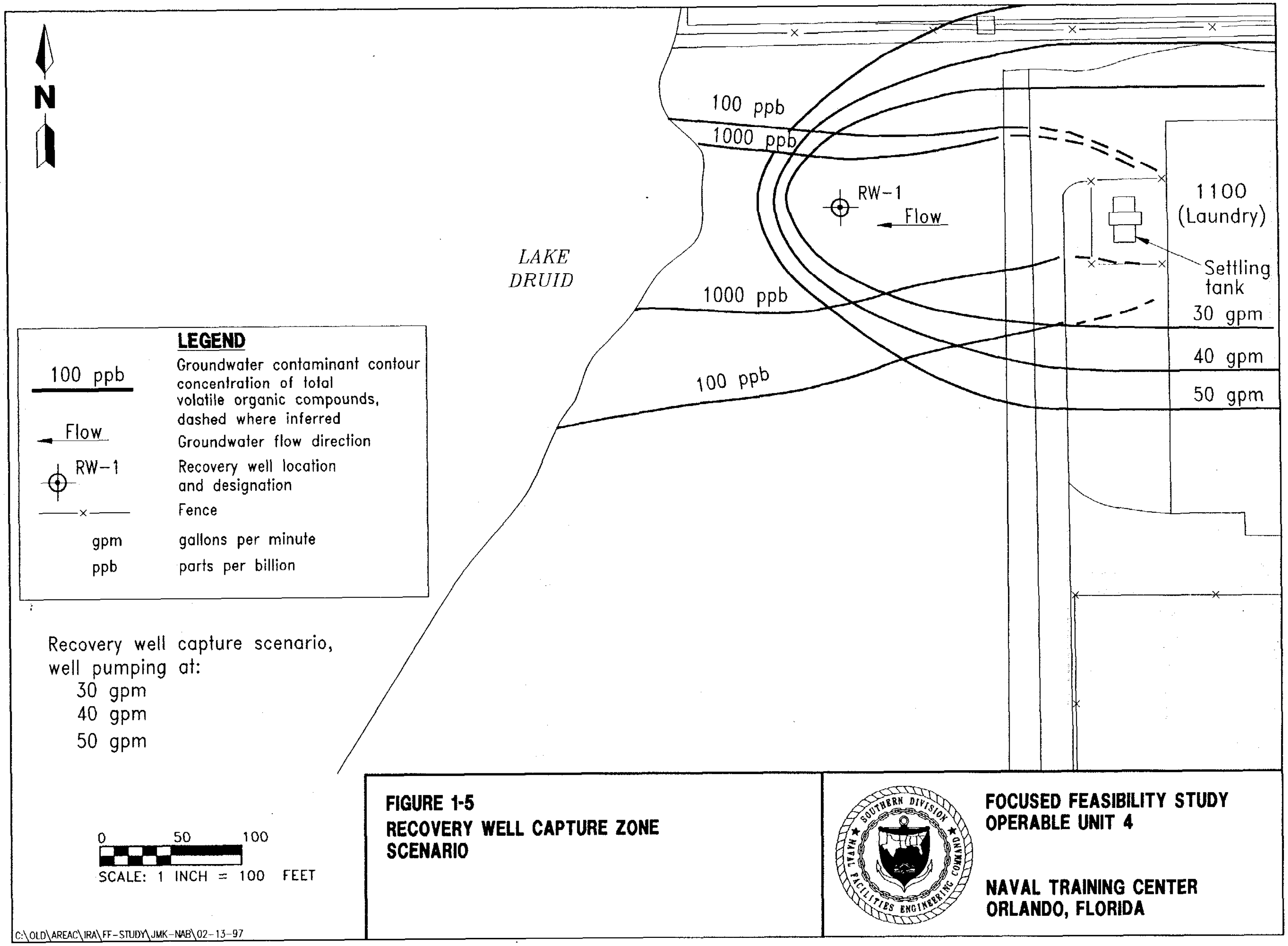

FIGURE 1-5
RECOVERY WELL CAPTURE ZONE SCENARIO

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OPERABLE UNIT 4

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- at 40 gpm, the downgradient distance from the recovery well to the point of stagnation of 37 feet (Figures 1-4 and 1-5 with supporting calculations included in Appendix A); and

- three groundwater samples were collected during the test at different time intervals to analyze groundwater quality during pumping, the results are included in Appendix B.

The pumping test demonstrated that, for the OU 4 IRA, hydraulic control provided through pumping, as opposed to interceptor trenches or other hydraulic control methods, would effectively contain the migration of the contaminant plume toward Lake Druid.

The data collected during the pumping test are used in subsequent remedial action considerations. Further detail of the pumping test can be found in the letter report, *Operable Unit 4 IRA Treatability Study: Pumping Test Implementation and Results (ABB-ES, 1996c)*.

1.2.2 Biological Conditions Limited sampling of groundwater and Lake Druid sediments was conducted to attempt to characterize the microbiological and redox conditions present in each medium. Reducing conditions were expected within the plume and in the lake sediment, as evidenced by the degradation of PCE to TCE and cis-DCE.

Three sediment samples were collected from Lake Druid and analyzed for methane, ethane, ethylene, sulfate, sulfide, nitrate, phosphate, ammonia, and chloride (Table 1-1). Groundwater at various points within the plume and one background location outside the plume was analyzed for dissolved oxygen, oxidation/reduction (redox) potential, methane, ethane, ethylene, nitrate, nitrite, and phosphate, (Table 1-2). Sulfate and sulfide were measured at the extraction well location during the pumping test (Table 1-2). See the Focused Field Investigation Report (ABB-ES, 1996b) for sample locations.

Lake Druid sediment sample results are consistent with methanogenic conditions, including the presence of methane (up to 22 mg/ℓ), no detectable concentrations of nitrate or sulfate, and the presence of sulfide. Ethylene and ethane were also detected, suggesting that some complete degradation of the chlorinated VOCs might be occurring within the sediments and/or upgradient groundwater.

The PCE degradation observed in groundwater confirms that reducing conditions must be present within the plume. The presence of methane (between 0.2 mg/ℓ and 6 mg/ℓ) and no detectable nitrate or nitrite within the plume are consistent with reducing conditions. Dissolved oxygen concentrations averaged 1.6 mg/ℓ, and redox potential varied between -52 and 74 millivolts, both higher than expected given the amount of PCE dechlorination observed. These values are also close to those measured at the background location. However, dissolved oxygen concentrations (particularly below 2 mg/ℓ) can be difficult to measure accurately using typical field instruments. Redox measurements are strongly dependent on sampling technique and may be much lower within the plume.

The above evaluation is preliminary and is based on a small number of samples collected in only one sampling round. A specific sampling program to more thoroughly evaluate conditions in sediment and groundwater will be developed during the remedial investigation (RI) for OU 4. A more detailed and conclusive assessment will be provided in the RI report.

Table 1-1
Sediment Treatability Analytical Results

Focused Feasibility Study
Operable Unit 4
Naval Training Center
Orlando, Florida

Sample ID	U4D01002	U4D01003	U4D01403
Methane (mg/ℓ)	0.373	21.977	0
Ethylene (mg/ℓ)	0	0.02	0
Ethane (mg/ℓ)	0.006	0.079	0
Nitrate (mg/kg)	< 1.3	< 1.3	< 1.3
Phosphate (mg/kg)	< 5	< 5	< 5
Chloride (mg/kg)	5	10	35
Sulfate (mg/kg)	< 16.3	< 19.0	< 27.3
Sulfide (mg/kg)	6.5	76.0	383
Ammonia (mg/kg)	< 5	< 5	< 5
Total organic carbon (mg/kg)	41,700	21,600	222

Notes: ID = identification.
mg/ℓ = milligrams per liter.
mg/kg = milligrams per kilogram.
< = less than.

Table 1-2
Groundwater Treatability Analytical Results

Focused Feasibility Study
Operable Unit 4
Naval Training Center
Orlando, Florida

Location	OLD-13-OW1	OLD-13-15A	OLD-13-16B	OLD-13-09A	OLD-13-10B	OLD-13-05A	OLD-13-06B
DO (mg/ℓ)	1.4	1.86	0.71	2.21	2.01	1.6	1.27
Redox (mV)	2.6	74.2	45.2	-52.6	-44.2	45.6	-3.1
Methane (mg/ℓ)	0.031	0.574	0.020	0.073	0.106	0.016	0.017
Ethane (mg/ℓ)	< 0.004	< 0.004	< 0.004	< 0.004	< 0.004	< 0.004	< 0.004
Ethylene (mg/ℓ)	< 0.003	< 0.003	0.005	< 0.003	< 0.003	< 0.003	< 0.003
Nitrate (mg/ℓ)	< 0.25	< 0.25	< 0.25	< 0.25	< 0.25	< 0.25	< 0.25
Nitrite (mg/ℓ)	< 0.1	< 0.1	< 0.1	< 0.1	< 0.1	< 0.1	< 0.1
Phosphate (mg/ℓ)	2	1	3	2	1	2	4

Notes: DO = dissolved oxygen.
mg/ℓ = milligrams per liter.
mV = millivolt.
< = less than.

1.2.3 <u>Contaminant Mass Flux</u> To assess the contribution of dissolved chemicals in groundwater to surface water contamination in Lake Druid, the mass flux of chemicals within different media was evaluated. The contaminant mass flux evaluation is the cornerstone in the decision-making process as to which media would be the focus of the IRA. The results indicate that the major contributor to the VOC contamination in Lake Druid is groundwater, and that the mass of contaminants measured in the sediment could easily be explained by sorption from the contaminated groundwater discharging through the bottom of Lake Druid.

1.2.3.1 **Groundwater** Preliminary calculations indicate that total VOCs entering Lake Druid via groundwater are approximately 24 pounds per year (Appendix C). This value is based on average contaminant concentrations in the plume, and the cross-sectional area of the plume as shown on Figure 4-4 of the IRA FFI Report for OU 4.

The shallow portion of the plume with total VOCs greater than 1,000 $\mu g/\ell$ was considered separately from the portion of the plume where VOC concentrations are between 1,000 $\mu g/\ell$ and 100 $\mu g/\ell$. The high concentration portion of the plume is shown in red on Figure 4-4 of the IRA FFI Report for OU 4. The cross-sectional area of this portion of the plume is approximately 840 square feet. VOC concentrations measured in groundwater during the direct push program were used to calculate the average concentration of each constituent. The average total VOC concentration is approximately 1250 $\mu g/\ell$, including 22 $\mu g/\ell$ PCE, 590 $\mu g/\ell$ TCE, and 635 $\mu g/\ell$ cis-DCE. The Darcy velocity was used to represent groundwater flow rates for this calculation. The Darcy velocity (0.39 ft/day) is the product of the hydraulic conductivity (32.7 ft/day, from the pumping test) and the natural hydraulic gradient of 0.012 feet per foot (ft/ft). (Note: the hydraulic gradient has been revised slightly from the value of 0.017 ft/ft reported in the FFI Report for OU 4). The above values were used to calculate a total mass flow of approximately 9 pounds per year (lb/year) total VOCs entering Lake Druid from the shallow high concentration zone.

Because the size of the portion of the plume where VOC concentrations are between 100 $\mu g/\ell$ and 1,000 $\mu g/\ell$ (shown in blue on Figure 4-4 of the FFI) is much greater than the high concentration portion, total VOCs entering Lake Druid from this deeper, lower concentration zone are greater (approximately 14 lb/year) than the amount from the shallow "hot" zone. Again referring to Figure 4-4 of the IRA FFI Report, the cross-sectional area of this lower concentration zone is approximately 4,500 square feet. The average total VOC concentration is 355 $\mu g/\ell$, including 153 $\mu g/l$ PCE, 102 $\mu g/\ell$ TCE, and 100 $\mu g/\ell$ cis-DCE.

The zone where VOC concentrations are between 10$\mu g/\ell$ and 100 $\mu g/\ell$ (Figure 4-4, shown in yellow) was also considered. However, the size and shape of this zone is somewhat speculative, due to the limited analytical data available in this area. Total VOCs entering Lake Druid from this zone are only 1 lb/year, based on an average total VOC concentration of 19 $\mu g/\ell$ and an area of 7,435 square feet.

It should be noted that these calculations considered only advection and did not consider dispersion, sorption, or degradation of the VOCs. However, the cross-section represented by Figure 4-4 is fairly close to the lakeshore, minimizing the effects of dispersion, sorption, and degradation on the results of the calculation.

The total VOCs of 24 lb/year can be put into perspective by converting the TCE and cis-DCE degradation byproducts into PCE equivalents. The 24 lb/year of mixed contaminants is equivalent to 32 lb/year of pure PCE, or approximately 2.3 gallons of pure PCE. This value is entirely reasonable, considering PCE releases from the laundry were likely small in size.

1.2.3.2 Lake Druid Lake sediment data collected during the FFI were used to estimate the total mass of VOCs in Lake Druid sediment. Sediment VOC concentrations (expressed in $\mu g/kg$ dry sediment) cannot be directly compared to VOC concentrations in groundwater (expressed in $\mu g/\ell$ of water).

Figure 4-2 from the IRA FFI Report presents the range of VOC concentrations in the lake sediment. The highest concentrations were measured in sediment along a 300-foot-long strip of shoreline, extending approximately 40 feet out into the lake, representing an area of 12,300 square feet. Typical concentrations ranged from 100 $\mu g/kg$ to 1,000 $\mu g/kg$. However, total VOC concentrations of 4,500 $\mu g/kg$ and 147,000 $\mu g/kg$ were detected at two locations.

Eighteen sediment analyses performed within the 12,300-square-foot zone were averaged to arrive at an average total VOC concentration of 8,800 $\mu g/kg$. This average includes the two very high samples and is therefore likely biased high with respect to the actual average concentration in this portion of the lake. Excluding the 147,000 $\mu g/kg$ sample would reduce the average total VOC concentration to 647 $\mu g/kg$. The median concentration of the 18 samples was 244 $\mu g/kg$.

The total mass of VOCs in Lake Druid sediment was calculated using the average concentration of 8,800 $\mu g/kg$, an average dry sediment density of 125 pounds per cubic foot (lb/ft^3), and a sediment thickness of 1 foot across the 12,300 ft^2 area (total volume of 12,300 ft^3). This calculation yields a total mass of VOCs in Lake Druid sediment of approximately 13.5 pounds (Appendix D).

A calculation excluding the 147,000 $\mu g/kg$ sample and using the average VOC concentration of 647 $\mu g/kg$ would yield a total mass of 1 pound of VOCs in Lake Druid sediment. Considering possible variations in the volume of contaminated sediment and the difficulties associated with accurately sampling a heterogenous medium such as saturated sediment, we believe a reasonable range for the total mass of VOCs in Lake Druid sediment is between 1 and 5 pounds.

1.3 SITE CONCEPTUAL MODEL.

The site conceptual model (SCM) for OU 4 has been continually refined based on results from each field investigation. The initial SCM considered two scenarios for contaminant source release and two potential release pathways for contaminant migration. The contaminant source release scenarios included the following:

- operational spills either on the ground surface outside the building or in the drain system and/or
- seepage from the settling tank located to the west of the facility.

The pathways initially considered were the following:

- transport of the chlorinated solvents by stormwater runoff into a drainage swale and culvert, and thereby directly to the lake; and

- seepage of chlorinated solvents through the soil and into the groundwater, thereby affected by groundwater flow and migrating to the lake.

As directed by the Navy and the OPT, the FFI did not focus heavily on the source release mechanism, but rather the potential release pathways. Therefore, one or both scenarios for source release may still hold true.

As intended, following the flowchart (Figure 1-2) that provides the logic for decision making for the IRA, the FFI results were sufficient to determine the pathway of contaminant migration. By taking the results of all previous investigations and analyzing them both separately and as a whole, the pathway for contaminant migration is determined to be from chlorinated solvents seeping into the groundwater and migrating via groundwater flow into Lake Druid. Key components of the investigation that confirm this are as follows:

- drive point wells along the lakeshore and in the creek, indicating vertical upward gradient;
- based on initial site screening and the IRA FFI results, the extent of VOCs within the groundwater extend from Building 1100 to Lake Druid; and
- surface water and sediment VOC plume configuration and concentrations, which mirror that of the groundwater VOC plume.

A revised site conceptual model is shown as Figure 1-6. Refinement of the SCM will continue through the overall RI/FS for the project.

__1.4 OVERVIEW OF FFS__. The remainder of this FFS report presents the RAOs for the IRA, technologies and alternatives considered for implementation that meet those objectives, and the recommended approach for the OU 4 IRA.

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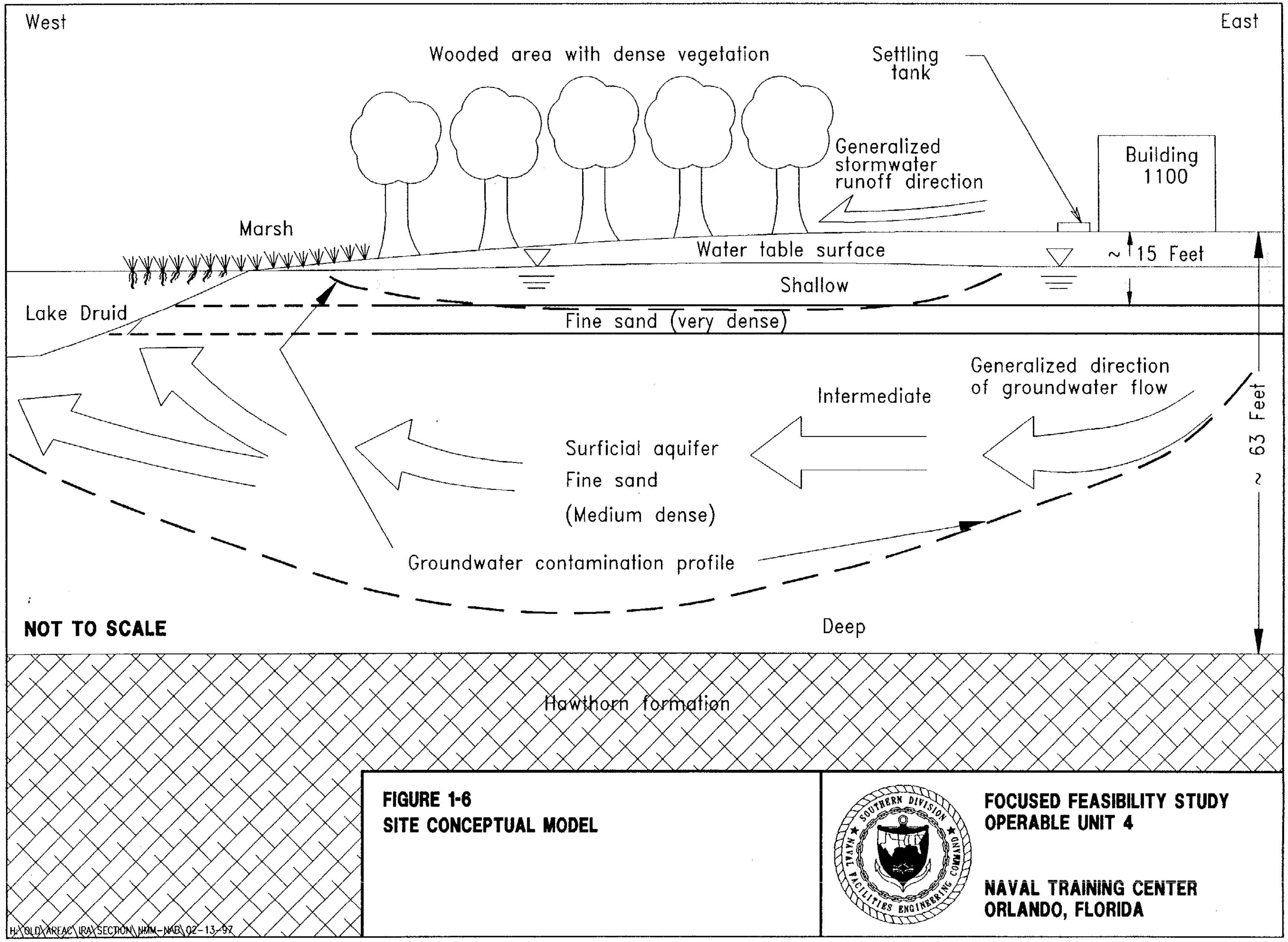

FIGURE 1-6
SITE CONCEPTUAL MODEL

FOCUSED FEASIBILITY STUDY
OPERABLE UNIT 4

NAVAL TRAINING CENTER
ORLANDO, FLORIDA

2.0 REMEDIAL ACTION OBJECTIVES

This section presents the goals and objectives for remedial action at OU 4 that provide the basis for selecting appropriate RAOs, and subsequently, identifying remedial technologies and developing alternatives for the IRA. To establish these objectives, regulatory requirements for the IRA were identified (Section 2.1). Next, RAOs are defined based on consideration of regulatory requirements, the conceptual model for the site, the Preliminary Risk Evaluation (PRE), and other criteria (Section 2.2). Section 2.3 identifies chemicals of concern at the site, and Section 2.4 identifies treatment levels, or the concentration of a chemical that a treatment technology would achieve if implemented. Finally, estimated physical characteristics of the media of concern are summarized (Section 2.5). Information presented in this section will be used to identify appropriate remedial technologies for the IRA at OU 4 (i.e., Chapter 3.0).

2.1 REGULATORY REQUIREMENTS. Regulatory requirements, or applicable or relevant and appropriate requirements (ARARs), are Federal and State human health and environmental requirements used to define the appropriate extent of site cleanup, identify sensitive land areas or land uses, develop remedial alternatives, and direct site remediation.

NTC, Orlando is not listed on the National Priorities List (NPL), and, therefore, remedial action at NTC, Orlando is not directed by the Comprehensive Environmental Response, Compensation, and Liability Act (CERCLA). Instead, remedial action at NTC, Orlando is directed by the Navy's Installation Restoration (IR) program. In this manner, "Applicable or Relevant and Appropriate Requirements (ARARs)," under the CERCLA definition set forth in the National Contingency Plan (NCP), are not directly appropriate for use at NTC, Orlando. However, remedial activities at NTC, Orlando that are conducted in accordance with the IR program are being conducted in a manner similar to CERCLA guidance. Therefore, ARARs, in the form of regulatory requirements, are identified in this section.

Remedial actions discussed in this FFS are for an IRA, and therefore, these actions should, to the extent practicable and considering the exigencies of the situation, achieve the identified State and Federal ARARs. To determine practicality, the scope of the IRA should be considered; the intent of this IRA is to minimize and/or mitigate potential harm from contamination rather than totally eliminate it. Therefore, even though a specific Federal or State regulation may be an ARAR for a particular medium, it may be outside the scope of the IRA. Such standards may still be an ARAR for future remedial action taken at the site.

Regulatory requirements for OU 4 are presented in Table 2-1. The requirements are categorized as follows:

- chemical-specific (i.e., governing the extent of site remediation with regard to specific contaminants and pollutants)
- location-specific (i.e., governing site features such as wetland, floodplains, and sensitive ecosystems and pertaining to existing natural and manmade site features such as historical or archaeological sites)

Table 2-1
Synopsis of Federal and State Regulatory Requirements for OU 4

Focused Feasibility Study
Operable Unit 4
Naval Training Center
Orlando, Florida

Name and Regulatory Citation	Description	Consideration in the Corrective Action Process	Type
Resource Conservation and Recovery Act (RCRA) Regulations, Identification and Listing of Hazardous Wastes [40 CFR Part 261]	Defines listed and characteristic hazardous wastes subject to RCRA. Appendix II contains the Toxicity Characteristic Leaching Procedure.	These regulations would apply when determining whether waste onsite is hazardous either by being listed or exhibiting a hazardous characteristic as described in the regulations.	Chemical-specific Action-specific
Endangered Species Act Regulations [50 CFR Parts 81, 225, 402]	The Act requires Federal agencies to take action to avoid jeopardizing the continued existence of federally listed endangered or threatened species.	If a site investigation or remediation could potentially affect an endangered species, this regulation would apply.	Location-specific
National Environmental Policy Act (NEPA) Wetlands, Floodplains, Important Farmland, Coastal Zones, etc. [40 CFR § 6.302-(a)]	Contains the procedures for carrying out the executive order on wetland protection (EO 11990). Requires Federal agencies to minimize the degradation, loss, or destruction of wetlands, and take steps to preserve and enhance the natural and beneficial value of wetlands.	When choosing a remedial action, any possible impact to wetlands should be considered and mitigated.	Location-specific
NEPA Regulations, Floodplain Management (EO 11988), 40 CFR Part 6, Appendix A]	Appendix A sets forth policy for carrying out EO 11988. This order requires that a cleanup in a floodplain not be performed unless a determination is made that no practicable alternative exists. If no alternative exists, potential harm must be minimized and action taken to restore and preserve the natural and beneficial value of floodplains (e.g., reduction and control of flood hazards; replenishment of groundwater; soil conservation; conservation and long-term productivity of existing flora and fauna).	Removal actions in a floodplain should consider alternatives to reduce risk of flood loss, minimize impact of floods on human safety, health and welfare, and restore and preserve floodplains. The potential effects of any action will be evaluated to ensure that the planning and decision making reflect consideration of flood hazards and floodplain management, including restoration and preservation of natural, undeveloped floodplains.	Location-specific
Clean Water Act (CWA) Regulations, NPDES [40 CFR Part 122 and 125]	Requires permits for discharge of any pollutant into the navigable waters of the United States. Permits specify allowable concentrations of contaminants that may be present in the effluent stream.	Remedial alternatives that involve discharging pollutants to navigable water will require a NPDES permit.	Action-specific
CWA, General Pretreatment Regulations for Existing and New Sources of Pollution [40 CFR Part 403]	Regulations for the introduction of pollutants from nondomestic sources into POTWs, to control pollutants that pass through, cause interference, or are otherwise incompatible with treatment processes at a POTW.	If groundwater is discharged to a POTW, the discharge must meet local limits imposed by the POTW.	Action-specific

See notes at end of table.

Table 2-1 (Continued)
Synopsis of Federal and State Regulatory Requirements for OU 4

Focused Feasibility Study
Operable Unit 4
Naval Training Center
Orlando, Florida

Name and Regulatory Citation	Description	Consideration in the Corrective Action Process	Type
Safe Drinking Water Act (SDWA) Regulations, MCLs [40 CFR Part 141, Chapter B]	Establishes enforceable standards for potable water for specific contaminants that have been determined to adversely affect human health.	MCLs can be used for groundwater or surface waters that are current or potential drinking water sources.	Chemical-specific
NESHAP [40 CFR Part 61]	Regulates specific sources of pollution. Requires these sources to meet emission standards based on maximum available control technology. Section contains NESHAP for perchloroethylene dry-cleaning sources.	Although these requirements are not generally applicable to CERCLA activities since the sources regulated are not present, the emission limitations for certain pollutants (e.g., perchloroethylene) may be considered.	Chemical-specific TBC
Florida Surface Water Quality Standards [62-302, FAC]	Rule distinguishes surface water into five classes based on designated uses and establishes ambient water quality standards (called Florida Water Quality Standards) for listed pollutants.	Because these standards are specifically tailored to Florida waters, they should be used to establish cleanup levels rather than the Federal Ambient Water Quality Criteria.	Chemical-specific
Florida Groundwater Classes, Standards and Exemptions [62-520, FAC]	Rule designates the groundwaters of the State into five classes and establishes minimum "free from" criteria. Rule also specifies that classes I & II must meet the primary and secondary drinking water standards listed in Chapter 62-550, FAC.	These regulations should be used to determine cleanup levels for groundwater.	Chemical-specific
Florida Drinking Water Standards [62-550, FAC]	Rule adopts Federal primary and secondary drinking water standards and also creates additional rules to fulfill State and Federal requirements for community water distribution system.	These regulations apply to remedial activities that involve discharges to potential sources of drinking water.	Chemical-specific
Pretreatment Requirements for Existing and New Sources of Pollution [62-625, FAC]	Rule establishes the authority of various bodies to implement pretreatment standards to control pollutants that pass through or interfere with treatment processes in domestic wastewater facilities.	The regulation would apply to remedial activities involving the discharge of remediation waters to a POTW.	Chemical-specific
Florida Water Quality Based Effluent Limitations [62-650, FAC]	Requires that all activities and discharges, except dredge and fill, must meet effluent limitations based on technology or water quality. WQBELs are determined by FDEP based on the characteristics of the receiving discharge, the receiving water, and the surface water criteria promulgated by FDEP.	The regulation would apply to remedial alternatives that discharge contaminated groundwater to surface water.	Chemical-specific

See notes at end of table.

Table 2-1 (Continued)
Synopsis of Federal and State Regulatory Requirements for OU 4

Focused Feasibility Study
Operable Unit 4
Naval Training Center
Orlando, Florida

Name and Regulatory Citation	Description	Consideration in the Corrective Action Process	Type
Florida Wastewater Facility Permits [62-620, FAC]	Establishes requirements for wastewater permits. Because Florida is a designated state (i.e., has the authority to implement the NPDES permits), one permit will suffice to meet both Federal and State discharge requirements.	If an offsite CERLCA activity or non-CERCLA remedial activity involved the discharge of wastewater to navigable waters, a permit meeting the requirements of this rule would be needed.	Action-specific
Florida Rules on Permits [62-4, FAC]	Provides permitting requirements for water pollution sources and air emissions units.	The regulation would apply to offsite CERCLA activities or non-CERCLA remedial activities requiring air emissions or water discharge permits.	Action-specific
Groundwater Guidance, Bureau of Groundwater Protection, June 1994.	The document provides maximum concentration levels of contaminants for groundwater in the State of Florida. Groundwater with concentrations less than the listed values are considered "free from" contamination.	The values in this guidance should be considered when determining cleanup levels for groundwater. Although these values are not promulgated, FDEP considers them ARARs for cleanup.	Chemical-specific

Notes: OU = Operable Unit.
CFR = Code of Federal Regulations.
EO = Executive Order.
NPDES = National Pollutant Discharge Elimination System.
POTW = publicly owned treatment works.
MCL = maximum contaminant level.
NESHAP = National Emission Standards for Hazardous Air Pollutants.
CERCLA = Comprehensive Environmental Response, Compensation, and Liability Act.
TBC = to be considered.
FAC = Florida Administrative Code.
WQBEL = water quality-based effluent limitation.
FDEP = Florida Department of Environmental Protection.
ARAR = applicable or relevant and appropriate requirement.

- action-specific (i.e., pertaining to the proposed site remedies and governing the implementation of the selected site remedy)
- advisories or guidance (to be considered [TBC])

TBCs are Federal and State nonpromulgated advisories or guidance that are not legally binding and do not have the status of being a potential regulatory requirement (have not been promulgated by statute or regulation). However, if there are no specific regulatory requirements for a chemical or site condition, or if regulatory requirements are not deemed sufficiently protective, then guidance or advisory criteria should be identified and used to ensure the protection of human health and the environment.

In the detailed analysis of alternatives (Chapter 4.0), each alternative will be analyzed to determine its compliance with these requirements.

2.2 IDENTIFICATION OF RAOs. RAOs are site- and media-specific goals that are established to protect human health and the environment, and are typically based on chemicals of concern, exposure routes, and receptors present or available at the site. RAOs are developed to ensure compliance with regulatory requirements. RAOs for OU 4 are identified based on existing site information, including the refined site conceptual model, regulatory requirements, the PRE, status of NTC, Orlando base closure, and progress of the overall RI/FS for the OU.

Refined Site Conceptual Model. The results of the FFI indicate that contaminated groundwater within the surficial aquifer between Building 1100 and Lake Druid is the most likely source of contamination to Lake Druid (ABB-ES, 1996b). PCE, TCE, and cis-DCE were detected in groundwater samples over the site (one isolated detection of VC), and Figure 1-3 presents a plan view of the site depicting total VOC concentrations. PCE, TCE, cis-DCE, and VC were detected in surface water and sediment samples collected from Lake Druid. The addition of VC in samples collected from the lake may indicate degradation of the chlorinated solvents as groundwater discharges to the lake (ABB-ES, 1996b).

Based on this conceptual model (see Figure 1-6), if groundwater containing total VOCs greater than 100 $\mu g/\ell$ were intercepted or controlled, the concentrations of VOCs in the lake would most likely decrease over time.

OPT Concerns. Investigations at OU 4 to date have shown that TCE is present in surface water above its Florida surface water standard, and other chlorinated solvents (PCE, cis-DCE, DCE, and VC) have also been detected (PCE and DCE at concentrations less than their respective Florida surface water standards; no standards are available for cis-DCE or VC). The State of Florida has indicated that the presence of these VOCs in surface water is a concern, as the potential for human or ecological receptor exposure to surface water is present.

Also, the OU 4 IRA was discussed at the November and December 1996 OPT meetings. An evaluation of conditions and viable alternatives for the IRA was completed; this information is presented in Appendix C of this FFS. Based on this evaluation and as discussed in the OPT meetings, it was determined that the focus of the IRA would be to gain control over the migration of contaminated groundwater discharging to Lake Druid. In this manner, a source of sediment and surface water contamination would be addressed. It was also affirmed that remedial action is necessary for groundwater as opposed to remedial action for sediment alone. If only sediment were addressed, the source of sediment contamination (groundwater) would continue to discharge VOCs to the Lake. It was recommended that conditions in the Lake should be monitored during the IRA for groundwater, and that these data be evaluated in the RI/FS for the site. At any time, an additional IRA for sediment or surface water could be implemented.

PRE Conclusions. A PRE was conducted for the site during the site screening phase of this project (ABB-ES, 1996a). The PRE estimated potential risk to human and ecological receptors based on existing data available for OU 4 (prior to the FFI) and current and future exposures to contaminated media. Conclusions of the PRE were as follows:

- There are no human or ecological receptor direct contact exposures to groundwater and subsurface soil at OU 4 under current land-use conditions.

- Additional data are necessary to determine the nature and extent of potential groundwater and subsurface soil contamination in the vicinity of the residential property.

- Based on existing data, and under current land-use conditions, a potential may exist for VOC vapor migration from groundwater and subsurface soil to ambient air in aboveground structures.

- Potential future human receptor exposures to PCE, TCE, arsenic, and beryllium in groundwater used as a residential source of water may pose cancer and noncancer risks above USEPA acceptable risk levels (this pathway was evaluated even though groundwater is not currently used as a drinking water source in this vicinity of NTC, Orlando).

- Based on available sampling and analytical data, potential exposures to VOC contamination in surface water and sediment from recreational swimming may pose a human health risk above the FDEP acceptable risk threshold. Additionally, this risk estimate does not consider additive exposures from other surface water and sediment exposure pathways that could potentially exist.

Overall RI/FS. The purpose of this report is to evaluate interim remedial alternatives until the RI/FS for the OU is complete. Considering this, along with other information discussed above, the IRA for OU 4 will focus on addressing a source of Lake Druid groundwater contamination. By addressing groundwater contamination, the mass of VOCs entering the lake should decrease over time.

The RI, scheduled to be conducted in 1997, will focus on refining the existing site conceptual model and, specifically, obtaining an understanding of the source of groundwater contamination and further evaluating groundwater flow into the lake. Additionally, the FS, scheduled to be conducted in late 1997, will evaluate other remedial alternatives for groundwater and will evaluate remedial alternatives for all other media, as necessary (e.g., surface water, sediment, soil).

Summary. Based on the above considerations, the RAO established for the IRA at OU 4 is as follows:

- Gain control over migration pathways of VOC concentrations that contribute to exceedances of FDEP surface water standards in Lake Druid.

Based on the results of the FFI, if this objective is achieved, the concentrations of VOCs in surface water (Lake Druid) should decrease over time through natural attenuation. It should be noted that this objective will be reevaluated and redefined, if necessary, in the overall RI/FS for OU 4.

2.3 CHEMICALS OF CONCERN (COCs). This IRA, in accordance with the RAO, will focus on VOCs detected in media at the site (groundwater, sediment, and surface water) that contribute to contamination in Lake Druid, namely, PCE, TCE, cis-DCE, DCE, and VC.

2.4 TREATMENT LEVELS. Treatment levels were established for COCs in groundwater. Treatment levels for other chemicals in other media at OU 4 will be defined in the overall RI/FS.

If groundwater were addressed via a treatment alternative, it would be treated one of two ways: *in situ* or *ex situ*. Depending on the remedial alternative chosen, treatment levels (or the concentration of a chemical to which groundwater would be treated) would vary.

2.4.1 *In Situ* Treatment Levels To establish *in situ* treatment levels for groundwater at OU 4, the following criteria were considered:

- Federal maximum contaminant levels (MCLs)
- State of Florida MCLs
- Florida Groundwater Guidance Concentrations
- Florida Surface Water Quality Standards (FSWQS)

As per discussions with the State of Florida in the November and December OPT meetings, and consistent with the requirements of the State of Florida, the FSWQS have been selected as the treatment levels for COCs discharging to Lake Druid. Florida MCLs will be used for COCs without surface water standards. Table 2-2 presents *in situ* treatment levels for OU 4.

2.4.2 *Ex Situ* Treatment Levels *Ex situ* treatment levels would apply if groundwater were extracted from the aquifer for treatment. *Ex situ* treatment levels depend on (1) the concentration of a chemical in extracted groundwater, and (2) acceptance criteria of the receiving water for treated groundwater (e.g., groundwater, surface water, or local wastewater treatment plant). Any *ex situ* treatment alternative would be designed to treat chemicals in extracted groundwater at concentrations greater than these treatment levels.

Appendix A presents the analytical results of the three water samples collected during various points during the 18-hour pumping test for OU 4. This appendix provides data for not only COCs, but also for other analytical parameters (including inorganics). These data represent the concentrations of chemicals that would be expected in groundwater extracted from OU 4.

Table 2-2
Groundwater *In Situ* Treatment Requirements

Focused Feasibility Study
Operable Unit 4
Naval Training Center
Orlando, Florida

Chemical of Concern	Federal MCL (µg/ℓ)	Florida MCL (µg/ℓ)	Florida Groundwater Guidance Concentration (µg/ℓ)	Florida Surface Water Quality Standard (µg/ℓ)	*In Situ* Treatment Level (µg/ℓ)
cis-1,2-Dichloroethene	70	70	70	--	70
Tetrachloroethene	5	3	3	8	8
Trichloroethene	5	3	3	80	80
Vinyl chloride	2	1	1	--	1

Notes: MCL = maximum contaminant level.
µg/ℓ = micrograms per liter.
-- = not calculated.

2.4.2.1 **Treated Groundwater Discharged to Groundwater** An *ex situ* treatment alternative that included a discharge to groundwater component would be designed to treat chemicals whose concentrations are greater than MCLs (Federal or State). These treatment criteria (for COCs) are the same as the treatment levels for an *in situ* treatment alternative and are summarized in Table 2-2.

2.4.2.2 **Treated Groundwater Discharged to Surface Water** An *ex situ* treatment alternative that included a discharge to surface water component would discharge water to Lake Druid. The criteria considered for this discharge option are (1) the Florida surface water standards or the Federal ambient water quality criteria (where a Florida surface water standard was not available) or (2) background (upstream) concentrations, whichever is higher. Florida surface water standards considered at this step were for Class III surface water, as that is the classification of Lake Druid. A Class III designation means the surface water is used for recreation and propagation and maintenance of a healthy, well-balanced population of fish and wildlife.

To identify which chemicals in the extracted groundwater would require treatment prior to discharge to surface water, the maximum concentration of each chemical in extracted groundwater at OU 4 was compared to the selected surface water criteria. Chemicals for which treatment would be necessary and the percent removal that should be achieved prior to discharge to surface water are summarized in Table 2-3.

2.4.2.3 **Treated Groundwater Discharged to the Local Wastewater Treatment Plant** An *ex situ* treatment alternative that included a discharge to a wastewater treatment plant would discharge to the City of Orlando's Sewage Treatment Plant (STP). Currently, NTC, Orlando has an industrial user discharge permit (Number C062QA) with the City of Orlando for discharge of investigation-derived waste from OU 4 (this permit is provided as Appendix D). Additionally, the City of Orlando has indicated that they would further accept extracted groundwater from OU 4 as long as the following conditions are met:

- no individual VOC has a concentration greater than 10 $\mu g/\ell$
- total VOCs are not greater than 2,000 $\mu g/\ell$
- pH is greater than 5 and less than 8

These conditions are the treatment levels (or local limits) for a remedial alternative that includes discharge of treated groundwater to the Orlando STP and are summarized in Table 2-4. The Orlando STP indicated that the concentrations of inorganics present in samples from the extracted groundwater are acceptable for direct discharge to the treatment plant (i.e., pretreatment for inorganic chemicals is not necessary). Based on the local limits set by the STP, the percent removal, or the degree of pretreatment necessary, was calculated (see also Table 2-4).

2.5 PHYSICAL CHARACTERISTICS OF COCs. Table 2-5 presents physical characteristics of the COCs (PCE, TCE, cis-DCE, DCE, and VC). A brief explanation of the physical characteristics follows.

Specific gravity, also known as relative density, is defined as ratio of the density of a substance to the density of distilled water. The density of water

Table 2-3
Groundwater *Ex Situ* Treatment Requirements for Discharge to Surface Water

Focused Feasibility Study
Operable Unit 4
Naval Training Center
Orlando, Florida

Analyte[4]	Analytical Results from Samples of Extracted Groundwater (μg/ℓ)			*Ex Situ* Treatment Level for Discharge to Surface Water[1]	Percent Removal Required[5]
	ETP-1	ETP-2	ETP-3		
<u>Volatile Organic Compounds</u>[2] (μg/ℓ)					
1,1,2,2-Tetrachloroethane	ND (<20)	ND (<20)	ND (<20)	< 10.8 μg/ℓ annual average	--
1,1-Dichloroethene (DCE)	ND (<20)	ND (<20)	ND (<20)	< 3.2 μg/ℓ annual average	--
Carbon tetrachloride	ND (<20)	ND (<20)	ND (<20)	< 4.42 μg/ℓ annual average	--
Tetrachloroethene (PCE)	172	124	90	< 8.85 μg/ℓ annual average	95
Trichloroethene (TCE)	2,660	2,380	2,220	< 80.7 μg/ℓ annual average	97
<u>Inorganic Analytes</u>[3] (μg/ℓ)					
Beryllium, Total	ND (<3)	ND (<3)	ND (<3)	< 0.13 μg/ℓ annual average	--
Cadmium	ND (<1)	ND (<1)	ND (<1)	0.4 μg/ℓ hardness-based	--
Copper	ND (<5)	ND (<5)	ND (<5)	0.6 μg/ℓ hardness-based	--
Mercury, Total	ND (<0.2)	ND (<0.2)	ND (<0.2)	< 0.012 μg/ℓ	--
Silver, Total	ND (<5)	ND (<5)	ND (<5)	< 0.07 μg/ℓ	--
Zinc	45	40	25	34 μg/ℓ hardness-based	24

[1] *Ex situ* treatment requirement is the State of Florida surface water standard for Class III surface waters.
[2] Three organic chemicals, 1,1,2,2-PCE, 1,1-DCE, and carbon tetrachloride, were not reported at concentrations above detection limits. However, the surface water standard is less than the detection limit; therefore, the presence or absence of these chemicals cannot be verified at this time.
[3] The inorganic chemicals listed (except for zinc) were not reported at concentrations above detection limits. However, the surface water standard is less than the detection limit; therefore, the presence or absence of these chemicals cannot be verified at this time.
[4] Only analytes with respective Florida surface water standards are listed. Although other analytes were detected in ETP samples (e.g., cis-1,2-DCE), a surface water standard is not available for that compound.
[5] Percent removal calculated based on maximum detected value.

Notes: -- = Percent removal is not calculated for these analytes, as detection limits were higher than their respective surface water standards, and until surface water samples are reanalyzed to obtain lower detection limits, the presence or absence of this compound cannot be verified.
μg/ℓ = micrograms per liter.
ETP = Engineering Treatability Parameter.
ND = not detected.
< = less than.

Table 2-4
Groundwater *Ex Situ* Treatment Requirements for Discharge to Orlando STP

Focused Feasibility Study
Operable Unit 4
Naval Training Center
Orlando, Florida

Analyte	Analytical Results from Samples of Extracted Groundwater (μg/ℓ)			Mean of Detected Concentrations (μg/ℓ)	Orlando STP Discharge Criteria (μg/ℓ)	Overall Percent Removal Required
	ETP-1	ETP-2	ETP-3			
Volatile Organic Compounds[1] **(μg/ℓ)**						
cis-1,2-Dichloroethene (cis-DCE)	570	570	605	582	10	98.2
Tetrachloroethene (PCE)	170	125	90	128	10	92.2
Trichloroethene (TCE)	2,660	2,380	2,220	2,420	10	99.6
Inorganic Analytes (μg/ℓ)						
Calcium	5	ND	ND	2	NA	--
Magnesium	2,200	2,200	2,200	2,200	NA	--
Sodium	13,000	13,000	13,000	13,000	300,000	--
Aluminum	220	200	190	203	NA	--
Iron	490	370	350	403	NA	--
Lead	14	ND	ND	5	400	--
Zinc	45	40	25	37	1,000	--
Alkalinity	5.9	6.1	7.7	6.6	5.5 < x < 9.5	--
Chloride	22	21	23	22	NA	--
Hardness	32	24	22	26	NA	--
TDS	16	21	6	14	NA	--
Sulfide	0.2	0.2	0.2	0.2	NA	--

[1] Only chemicals detected in ETP samples are listed. Other chemicals of concern (e.g., vinyl chloride, and 1,1-DCE) were not detected in ETP samples.

Notes: STP = sewage treatment plant.
μg/ℓ = micrograms per liter.
ETP = Engineering Treatability Parameter.
ND = not detected.
NA = not applicable.
-- = not calculated, removal of chemical is not necessary prior to discharge to Orlando STP.
< = less than.
TDS = total dissolved solids.

Table 2-5
Characteristics of Chemicals of Concern

Focused Feasibility Study
Operable Unit 4
Naval Training Center
Orlando, Florida

CAS Number	Contaminant	Molecular Weight (g/mole)[1]	Specific Gravity[1]	Solubility (mg/ℓ) at 25°C[1]	Vapor Pressure (mmHg) at 25°C[1]	Henry's Law Constant (atm-m^3)/mole25°C[1]	Log K_{ow}25°C[2]	Log K_{oc}25°C[1]
156-59-4	cis-1,2-dichloroethene	97	1.27	3500	205	3.7 E-03	0.70	1.93
75-35-4	1,1-dichloroethene (total)	97	1.25	3,350	603	0.0255	1.8	1.81
127-18-4	tetrachloroethene	165.8	1.62	200	18.9	1.53 E-02	2.60	2.56
75-01-4	vinyl chloride[3]	62.5	0.97	2,800	2,660	1.2	1.4	1.99
79-01-6	trichloroethene	131.5	1.46	1100	75	9.10 E-03	2.38	2.10

[1] Pankow and Cherry. 1996. *Dense Chlorinated Solvents.* Ontario, Canada: Waterloo Press.
[2] Nyer, E. et al. 1996. *In Situ Treatment Technology* . Boca Raton, Florida: CRS Press.
[3] All vinyl chloride properties from: Agency for Toxic Substances and Disease Registry. 1991. *Draft Toxicological Profile For Vinyl Chloride.* (October).

Notes: CAS = Chemical Abstract System.
g/mole = grams per mole.
mg/ℓ = milligrams per liter.
°C = degrees Celsius.
mmHg = millimeters of mercury.
atm-m^3/mole = atmosphere-cubic meter per mole.
K_{ow} = octanol-water partition coefficient.
K_{oc} = soil-sediment partition coefficient.
NA = not available.

is 1.00 grams per milliliter (g/mℓ) at 4 degrees Celsius (°C). The density of a substance is an indicator of whether or not it will tend to sink or float in water.

Solubility is defined as a compound's saturated concentration in water at a given temperature and pressure.

Vapor pressure is defined as the pressure exerted by the vapor of a substance when it is under equilibrium conditions. The vapor pressure of all liquids increases with temperature. Vapor pressure provides a rough estimation of how well a substance will volatilize from soil and/or water. The vapor pressure of water at 20 °C is 18 millimeters of mercury (mmHg).

Henry's law constant (H), also known as the air-water partitioning coefficient, is defined as the ratio of a compound's partial pressure in air to the concentration of the compound in water at a given temperature and under equilibrium conditions. Henry's law constant provides an indication of the relative volatility of a substance. The following guidelines are for Henry's constants in atmospheres times cubic meters per mole (atm-m^3/mole).

$H > 10^{-3}$	rapid volatilization
$10^{-5} < H < 10^{-3}$	mid-range volatilization
$10^{-7} < H < 10^{-5}$	slow volatilization
$H < 10^{-7}$	extremely low volatilization

The octanol water partition coefficient, K_{ow}, is defined as the ratio of the solute concentration in the water-saturated octanol phase to the solute concentration in the octanol-saturated water phase. It is used to estimate the hydrophobicity and sorptive tendencies of hydrocarbons. For convenience, K_{ow} is often reported in logarithmic form ($\log K_{ow}$) because values from the class of immiscible hydrocarbons that are of environmental concern span several orders of magnitude. Negative $\log K_{ow}$ values indicate a preference for the aqueous phase (hydrophilicity). Positive $\log K_{ow}$ values indicate a hydrocarbon's preference to form separate phases (hydrophobicity), sorb strongly to solids, or potentially volatilize.

The soil and/or sediment partition coefficient, K_{oc}, is defined as the ratio of adsorbed chemical per unit weight of organic carbon to the aqueous solute concentration. K_{oc} is a measure of a chemical's relative adsorption potential, i.e., a chemical's tendency to sorb to particulate or organic matter. This is largely dependent on the organic content of soil. For convenience, K_{oc} is often reported in logarithmic form ($\log K_{oc}$) because values that are of environmental concern span several orders of magnitude. Sorption is generally considered to be high for $\log K_{oc}$ values of 5 to 6, moderate for $\log K_{oc}$ values of 3, and weak for values of 2.2 or less. Compounds that bind strongly to organic carbon have low solubilities, whereas compounds that do not tend to adsorb to organic materials have high solubilities.

3.0 REMEDIAL ACTION ALTERNATIVES

The approach and rationale leading to the development of interim remedial alternatives for groundwater for the OU 4 IRA are presented in this chapter. The development of alternatives consists of identifying applicable technologies, screening those technologies, and using the selected technologies to develop remedial alternatives to accomplish the identified RAO.

3.1 IDENTIFICATION AND SCREENING OF REMEDIAL TECHNOLOGIES. The primary goal of alternative development for the OU 4 IRA is to gain control over the migration pathways of VOC concentrations in groundwater that contribute to surface water exceedances in Lake Druid. This goal was established in Chapter 2.0. Because site characterization has not been fully completed at OU 4 (i.e., the overall RI/FS is yet to be completed), treatment alternatives were developed in this chapter using a streamlined process that considers achievement of the RAO, effectiveness, implementability, and cost for this IRA.

Evaluation of complex or innovative technologies (e.g., *in situ* treatment technologies such as permeable reactive walls) generally requires a more complete site characterization than is available at this stage (prior to the completion of the RI/FS); nonetheless, several innovative technologies were considered for this IRA.

Plume immobilization techniques, such as subsurface barriers, may reduce migration of contamination, but do not provide reduction in toxicity or volume of contaminants in the aquifer. Alternatively, groundwater extraction or transformation treatment processes are a means to either hydraulically control gradient (groundwater extraction) and/or provide treatment of chemicals present in the media (groundwater extraction and transformation treatment processes).

Technologies considered for this IRA have been categorized based on their basic operating principles. One representative technology was then selected from each technology type for subsequent screening. This approach allows an effective comparison of technologies based on their basic operating principles rather than more subtle vendor-specific characteristics or variable configuration.

Supplemental technologies may be required for residuals and emissions generated during groundwater treatment. For example, the vapor collection portion of an air stripping system may require treatment of organic vapors prior to exhaust. The effective treatment of residuals and emissions is dependent upon the treatment used. Thus, the identification of required supplemental technologies will be deferred to the detailed evaluation of remedial alternatives (Chapter 4.0).

The following subsections discuss the identification and screening of groundwater treatment technologies.

3.1.1 Identification of Groundwater Collection Technologies To implement *ex situ* treatment technologies, contaminated groundwater must be extracted from the aquifer. The practicality of groundwater extraction depends on the hydrogeologic conditions at a site. To evaluate these conditions, a pumping test was conducted at OU 4 in August 1996 as indicated in Subsection 1.2.1.

Analysis of the pumping test data indicated that the recovery well provided good horizontal and vertical connection through the surficial aquifer. Results of the test indicated a hydraulic conductivity of 32.7 ft/day and a transmissivity of 1,960 ft^2/day. These values were used in subsequent design calculations. Further detail of the pumping test can be found in the OU 4 IRA Treatability Study: Pumping Test Implementation and Results letter report (ABB-ES, 1996c).

The pumping test demonstrated that, for the OU 4 IRA, hydraulic control, as opposed to interceptor trenches or other hydraulic control methods, can be provided through recovery well extraction method.

3.1.2 Discharge Options for Treated Groundwater If groundwater is treated via extraction and treatment, the process would produce an effluent that requires discharge. The method of discharge dictates the degree of treatment required. Specific discharge criteria for various discharge options are presented in Tables 2-2, 2-3, and 2-4 in Chapter 2.0. The following three discharge options have been identified for OU 4 and are described below:

- discharge to surface water
- reinjection to groundwater
- discharge to Orlando STP

3.1.2.1 Discharge to Surface Water Groundwater extracted and treated may be discharged to Lake Druid (i.e., surface water) via direct pipeline. Anticipated treatment levels for organic and inorganic compounds for a discharge to surface water component are presented in Table 2-3. These treatment levels will be used for developing an appropriate treatment process (for both organic constituents and inorganics constituents, as both treatment processes would be necessary) for extracted groundwater. However, actual treatment levels may be modified by FDEP. A National Pollutant Discharge Elimination System (NPDES) permit will be needed for discharge to the surface water.

3.1.2.2 Reinjection to Groundwater Treated groundwater may be reinjected into the aquifer. For the purposes of this evaluation, it is assumed that the effluent would have to achieve the treatment levels presented in Table 2-2. However, similar to surface water discharge, FDEP may modify these treatment levels on a case-by-case basis. Specifically, a zone of recharge could be established for reinjection of the discharge, and the specified treatment levels may not need to be achieved within this zone. According to Standards for Class G-I and Class G-II Groundwater (Chapter 62-520.420, Florida Administrative Code [FAC]), a zone of discharge allows for some mixing of the treated water and the aquifer, provided that the quality of groundwater outside that zone is not adversely affected. A request to discharge to groundwater would require FDEP approval.

3.1.2.3 Discharge to Orlando STP The Orlando STP relies primarily on its Bardenpho process to degrade organic matter prior to discharge. The STP is capable of providing treatment for extracted groundwater provided that constituents in the groundwater do not exceed the influent requirements (Table 2-4).

The advantage of a discharge to the STP is that existing treatment capacity is utilized and only pretreatment would be required to reduce selected constituent concentrations to a level that can be accepted as influent. Anticipated pretreatment requirements for discharge to the STP were presented in Table 2-4. TCE, PCE, and cis-DCE are the only groundwater constituents that exceed the treatment levels, and thus would require pretreatment consisting of 99.6, 92.2, and 98.2 percent removal, respectively.

3.1.2.4 **Screening of Discharge Option for Treated Groundwater** Considering that this FFS evaluates technologies for an IRA at OU 4, and based on consideration of implementability, effectiveness, and cost, the best option for discharge of extracted treated groundwater is to the Orlando STP for the following reasons:

- The Orlando STP would provide treatment of inorganic and other compounds found in extracted groundwater, and pretreatment for organic compounds, only, is necessary.

- An industrial user's permit is already in place between the Orlando STP and NTC, Orlando for treatment of investigation-derived wastes, and, therefore, a permit for discharge of treated water for the OU 4 IRA could be easily obtained. Alternatively, obtaining a permit for discharge to a surface water body (NPDES permit) may be time consuming for the timeframe considered for this IRA.

- The cost of discharge to the Orlando STP is minimal compared to the cost of a treatment system for inorganic compounds (if discharge were to a surface water body, an inorganic treatment step would be necessary).

Therefore, it is recommended that alternatives including groundwater extraction and treatment be developed to include discharge of treated water to the Orlando STP. In this manner, pretreatment for organic compounds, only, is necessary.

<u>3.1.3 Technologies for Treatment of Extracted Groundwater</u> In the previous subsection, it was recommended that extracted and treated groundwater be discharged to the Orlando STP. In this manner, pretreatment for organic compounds, only, is necessary. Treatment levels for this discharge option are presented in Table 2-4. This section presents treatment technologies to remove organic compounds from extracted groundwater to achieve these treatment levels.

3.1.3.1 **Oxidation** Oxidation involves destroying VOCs in groundwater by changing the oxidation state of target contaminants. This process is also effective for precipitating selected inorganic compounds, such as iron and other multivalent cations. Oxidation is usually not effective for the removal of semivolatile organic compound (SVOCs). Oxidation is attractive for use at contaminated sites, as the systems have very low, if any, air emissions.

The following four general categories of oxidation have been identified:

- ultraviolet light
- ozone
- hydrogen peroxide (H_2O_2)
- other chemical oxidants

<u>Ultraviolet Light</u>. Ultraviolet light oxidation (UV/OX) is a process that enhances chemical oxidation using the hydroxyl ion by exposing contaminated water to ultraviolet light. In this process, hydrocarbons are broken down into carbon

dioxide and water. Oxidizers typically used with UV/OX include H_2O_2 and/or ozone. UV/OX occurs in a stainless-steel chamber containing vertically or horizontally mounted ultraviolet lamps. The process is the same for either oxidant (i.e., H_2O_2 or ozone); however, the manner in which the oxidant is introduced into the waste stream may differ. H_2O_2 is blended into the waste stream prior to entering the reactor, and ozone is piped to a sparging tank or chamber and diffused as a gas into the reactor. UV/OX typically achieves more than 99 percent destruction efficiency of organic compounds. Pretreatment for removal of naturally occurring inorganics (e.g., iron, lead, or manganese) may be required to prevent fouling of the oxidation system. Treatability studies would be required to determine optimum operating parameters such as pH and chemical dosage if inorganic treatment is required.

Ozone. Ozone is a highly reactive gas that is typically generated onsite. It can be used alone or in combination with UV/OX. Alone, it is bubbled as a gas through diffusers into the water. In contrast to other types of chemical oxidants, ozone does not typically create organic residuals that remain in the waste stream after treatment. Ozone is an extremely powerful oxidant because it nonselectively oxidizes compounds dissolved in groundwater. However, ozone does have its limitations. Ozone is very reactive, and it may dissipate rapidly in natural water either by reacting with natural constituents or by spontaneous decomposition. The primary difference between ozone and other chemical oxidants is that ozone does not produce residuals (American Water Works Association, 1990).

H_2O_2. H_2O_2 is a moderately powerful liquid oxidizing agent that is usually shipped to the treatment plant and not generated onsite. H_2O_2 with ultraviolet light is generally a more effective oxidation process than H_2O_2 or ozone used alone. This process generates hydroxyl radicals that effectively oxidize VOCs and SVOCs (American Water Works Association, 1990).

Other Chemical Oxidants. Chlorine is an effective oxidant frequently used for the disinfection of water supplies. It can be added to water in liquid or gas form. Hypochlorous acid (HOCl) is the most effective form of chlorine for oxidation. However, if inappropriately applied, it can combine with organic matter to form trihalomethanes (THMs). THMs are potentially carcinogenic compounds, such as chloroform and bromoform (American Water Works Association, 1990). Other chlorinated compounds that can be used to oxidize organic matter include chloramines and chlorine dioxide. These compounds are generally less powerful oxidants than HOCl and are not as effective in oxidizing high concentrations of organic compounds (American Water Works Association, 1990).

Potassium permanganate is another chemical oxidant that has been used to treat organic compounds. Potassium permanganate is typically fed into a waste stream as either a solid or a liquid solution, prepared onsite. Potassium permanganate can be used to oxidize the majority of organic compounds, as well as selected inorganic compounds. However, similar to other chemical additives, precipitation from the application of potassium permanganate requires subsequent treatment and disposal (American Water Works Association, 1990).

Recommendation. When comparing various methods of oxidation, chlorine is typically used for the disinfection of water supplies. The advantage of chlorine is the formation of a chlorine residual. This residual continues to disinfect water through distribution systems or receiving water bodies. Those same residuals can also react with organic matter and form THMs. However, destruction of organic compounds, not disinfection, is the objective of oxidizing groundwater extracted from OU 4. Thus, UV/OX with ozone and/or H_2O_2 is a more effective oxidation technique. To minimize residuals created during oxidation and ensure complete destruction of organic compounds, UV/OX with H_2O_2 is selected as the representative oxidation technology for subsequent screening. It is anticipated that UV/OX with H_2O_2 can destroy VOCs and oxidize inorganic compounds for subsequent precipitation and removal.

Although UV/OX would be effective in this application, certain drawbacks exist. First, the capital cost for UV/OX equipment would be much higher than that for air stripping. Next, maintenance of a UV/OX system may require special training or an outside contractor for system components such as the ozone generator, the desiccant dryer, or the UV lamp assembly. Also, even though the system may operate with minimal attention, daily monitoring of the process water is required.

3.1.3.2 **Organic Adsorption** Adsorption is a process in which a substance is transferred from water to a solid medium. This technology is effective for VOCs and SVOCs. When compared to air stripping, aeration, and oxidation, organic adsorption is more effective for the removal of SVOCs.

The molecule that accumulates or adsorbs at the water-solid interface is called the adsorbate, and the solid on which the adsorption occurs is the adsorbent. Common adsorbents in water treatment include activated carbon, ion exchange resins, adsorbent resins, metal oxides, and carbonates. While some of these technologies are used primarily for the treatment of inorganic compounds, this discussion will focus on the following technologies for the treatment of organic compounds:

- granular activated carbon (GAC)
- powdered activated carbon (PAC)

GAC. GAC is a physical treatment technology in which groundwater is passed through a packed-bed reaction vessel filled with activated carbon. GAC adsorbs organic compounds and inorganic constituents. The particle shape of crushed activated carbon is irregular, while extruded activated carbon is smooth and cylindrical. The basic manufacturing process includes carbonization, or conversion of the raw material to a char, and activation (or oxidation) to develop the internal pore structure. Carbonization is usually performed in the absence of air at temperatures less than 700 °C (American Water Works Association, 1990).

GAC adsorption is applicable to different water flow rates and concentrations. Two GAC canisters are typically used in series to monitor breakthrough and to ensure treatment effectiveness. GAC can be used as either a polishing step or a pretreatment step, depending upon the other technologies used in the treatment system. The primary cost consideration is the regeneration or disposal of spent carbon.

PAC. PAC is used in a sequential process, by adding it to groundwater within a holding tank and then separating the water and PAC. After the PAC contacts the water, the carbon is allowed to settle, and the treated water is removed. PAC particles are typically smaller than GAC particles and are supplied in bulk rather than in canisters (Metcalf & Eddy, Inc., 1991).

PAC has advantages over GAC in that it has lower capital costs and allows greater flexibility in altering carbon doses as the water quality changes. The disadvantages are that the PAC can not be regenerated, it attains lower total organic carbon removal, the sludge in the bottom of the tank must be disposed of, and it is difficult to remove the spent carbon from the water.

Recommendation. These technologies have similar effectiveness in removing organic contaminants from groundwater. However, for comparative purposes, GAC will be used as the representative organic adsorption technology for screening. GAC is easy to implement and has demonstrated effectiveness for removing organic compounds, such as those present in groundwater at OU 4. If an alternate adsorption medium is identified that has advantages over GAC, it could also be used. An alternate adsorbent could be used in series with GAC or in place of GAC.

3.1.3.3 **Biological Treatment** Biological treatment is a common method of reducing the concentration of organic compounds in wastewater. The same techniques typically applied in wastewater treatment can be applied to groundwater treatment. PCE and TCE typically degrade faster under anaerobic conditions, while cis-DCE and lesser-chlorinated compounds degrade faster under aerobic conditions. Thus, both aerobic and anaerobic conditions (applied individually or sequentially) will be considered for biological treatment for the extracted groundwater. Biological treatment can be further categorized as either of the following processes:

- suspended growth
- attached growth

Suspended Growth. Suspended growth systems include digesters and activated sludge processes. In these systems, the active biomass that metabolizes organic matter is suspended in the liquid and requires subsequent separation. The most critical parameter in the operation of a suspended growth process is the "sludge age." The sludge age is the average cell residence time in the reaction tank, prior to removing and settling the accumulated biomass. A portion of the biomass is then returned to the reaction tank to stimulate continued microbial growth. This is a well-demonstrated, effective technology to biodegrade organic matter. The primary disadvantage is its susceptibility to toxic shocks, residuals created, and operations and maintenance (O&M) required to maintain an effective biomass.

Attached Growth. Attached growth systems include trickling filters, rotating biological contractors (RBCs), and packed-bed reactors. In these systems, the active biomass is attached to an inert medium and forms a "fixed film" to biologically filter organic matter. Attached growth can be effective in reducing the concentrations of organic matter that pass near the biomass. Frequent cleaning, stimulation, and distribution of the biomass along the surface of the medium are required to maintain effective treatment.

Recommendation. If biological treatment of extracted groundwater is desired, the best biological method that would achieve treatment levels established in Chapter 2.0 would be the City of Orlando's STP, which is considered a suspended growth biological process. However, as previously discussed, the Orlando STP has placed local limits on the influent water to its plant. These local limits (i.e., treatment levels) were discussed in Paragraph 2.4.2.3.

3.1.3.4 **Air Stripping and Aeration** Air stripping and aeration are used to remove VOCs from contaminated water. It is generally considered to be only partially effective for SVOCs. The VOCs are transferred from the liquid to the vapor phase by contacting the water with a continuous supply of clean air. Although many vendor-specific air stripping and aeration units exist, they can be grouped into the following four categories:

- packed towers
- diffused aeration
- cascade towers
- tray towers

Packed Towers. A typical packed tower system consists of a tower (or column) in which influent groundwater flows downward from the top, while a stream of air flows upward from the bottom. The tower is filled with an inert packing material. Plastic packing is usually used in water treatment operations and provides a large surface area for air-water interface. As clean air moves upward, the VOCs are transferred from the water to the airstream. The liquid effluent is discharged from the bottom, and the air containing VOCs is discharged from the top (American Water Works Association, 1990). The presence of inorganic compounds can potentially clog packing material. Frequent cleaning, adjustment, or replacement of packing may be required to maintain effective removal efficiencies (Dzombak et al., 1993).

Diffused Aeration. Diffused aeration is a process of bringing air bubbles into contact with contaminated water. This process is similar in principle to a packed tower, but it is typically accomplished by a "low profile" unit that requires less operating space. Air is bubbled into a tank containing contaminated water. A variety of aeration rates and bubble diffusers are available to achieve different effects. Diffused aeration generally requires a higher power cost than packed towers and can be accomplished in tanks (American Water Works Association, 1990). Similar to packed towers, inorganic compounds can be troublesome, potentially clogging diffuser mechanisms, requiring cleaning or replacement (Dzombak et al., 1993).

Cascade Towers. Cascade towers are gravity-fed, stepped systems that aerate contaminated water by continually "splashing" the water onto subsequent steps. Small pools of water are exposed to air as thin sheets cascade down each step. The number and height of the required steps can be designed to achieve the desired contact time for air-water interface (Metcalf and Eddy, 1991).

Tray Towers. Tray towers, such as low profile tray units, are similar in principle to cascade towers. Rather than a series of steps, a series of stacked trays are used to maximize air-water interface. Water flows over a flat tray, discharges to a lower tray, and continues to pass over the required number of trays to achieve the desired removal efficiency. Trays consist of porous bottoms, allowing for air to be forced through the tray as the water passes over the trays, increasing turbulence and aeration. Tray tower aeration maximizes air-water contact by using multiple trays. If a greater air-water contact time is desired, additional trays may be added (Peavy, Rowe, Tchobanoglous, 1985).

Recommendation. These air stripping and aeration technologies have similar effectiveness in volatilizing VOCs. Use of tray towers, such as low profile tray units with forced aeration, is a demonstrated technology that is easily obtained to achieve a variety of treatment levels. For comparative purposes, a low profile tray unit with forced aeration will be used as a representative air-stripping and aeration technology for subsequent screening. Alternate innovative or vendor-specific processes that accomplish the same type of treatment as air stripping could be used in lieu of a low profile tray unit.

3.1.3.5 **Screening of Technologies for Extracted Groundwater** The next step in the FFS process is to evaluate selected extracted groundwater treatment technologies with respect to certain criteria. This evaluation assists in selecting the most effective and economic treatment alternative. This evaluation for OU 4 considers evaluation criteria to be issues specific to the organic treatment technologies discussed in the previous subsection. These issues include process residuals and air emissions, required O&M activities, relative effectiveness compared to related technologies, and cost over 1 year of operation. The screening of selected extracted groundwater treatment technologies and recommendations are presented in Table 3-1.

Each of the technologies identified in Table 3-1 addresses the RAO for the OU 4 IRA. However, the advantages of an air stripping and aeration technology over an oxidation or adsorption technology, as presented in the table, are such that the air stripping and aeration technology was the selected technology for the OU 4 IRA.

3.1.4 *In Situ* Treatment of Groundwater *In situ* technologies are processes that are capable of removing organic compounds from groundwater without extracting the groundwater. In contrast to groundwater extraction and *ex situ* treatment, *in situ* treatment does not generate water requiring discharge. Additionally, only target organic constituents are treated, as opposed to treating nontarget organic constituents and inorganic compounds to achieve discharge limitations for extracted groundwater. *In situ* treatment technologies identified for OU 4 are presented below.

3.1.4.1 **Air Sparging** Air sparging is used to remove VOCs from groundwater without extracting the water. Air is injected into the saturated zone to create turbulence and volatilize organic compounds. As air moves up through the aquifer, contaminants partition into the gas phase and are then extracted as organic vapors from the vadose zone. Injected air can also stimulate microbial degradation of contaminants if the required microbes thrive in aerobic conditions (Johnson, Johnson, McWhorter, Hinchee, Goodman, 1993).

Air sparging is typically used in combination with soil vapor extraction (SVE) to control off-gas generated by organic compound volatilization. SVE uses negative pressure to collect extracted vapors. Vapor extraction wells or trenches are installed above the water table, in a configuration to capture vapors generated from air sparging. The spatial extent of effectiveness of an air sparging-SVE system can be enhanced by dewatering saturated soil.

Table 3-1
Screening of Organic Treatment Technologies for Extracted Groundwater

Focused Feasibility Study
Operable Unit 4
Naval Training Center
Orlando, Florida

Representative Technology	Residuals and Emissions	Operation and Maintenance	Relative Effectiveness	Cost (1 year)	Recommendation
Air Stripping and Aeration Tray Towers: Low profile forced aeration tray unit	May require off-gas treatment.	May require air emissions monitoring and treatment. Requires maintenance of cleaning trays.	Demonstrated effectiveness in treating VOCs.	$242,000	Retain.
Oxidation Ultraviolet light (UV/OX) with hydrogen peroxide	Generates intermediate organic byproducts if incomplete oxidation.	Requires chemical expertise for effective dosing. High power cost and maintenance supplies to produce ozone and UV light onsite.	Effectively destroys VOCs, to 99 percent destruction efficiency. Also effective in oxidizing inorganic compounds for subsequent removal.	$355,000	Eliminate. High capitol and O&M costs.
Organic Adsorption Granular activated carbon (GAC)	Produces spent carbon, which must be regenerated or disposed of.	Carbon must be changed and replaced.	Adsorption media is a well-demonstrated process to remove organic compounds. Adsorption is more effective than air stripping, aeration, or oxidation for the removal of SVOCs and other synthetic organics.	$292,000	Eliminate. High O&M labor and equipment costs.

Notes: VOCs = volatile organic compounds.
UV/OX = ultraviolet light oxidation.
O&M = operation and maintenance.
GAC = granular activated carbon.
SVOCs = semivolatile organic compounds.

Other types of *in situ* aeration techniques include steam stripping and bioventing. These techniques are generally targeted for residual contamination adsorbed to soil in the vadose zone. They are effective in treating selected contaminants in soil, but are limited in their application to groundwater. Thus, they will not be used for the development of remedial alternatives for the OU 4 IRA.

3.1.4.2 **Recirculation/In-Well Stripping** Recirculation well technology creates a circulation sphere within the affected portion of the surficial aquifer. Typically, groundwater enters through a screen in the lower part of the recirculation well, travels up through the well, and returns to the aquifer through a screen near the top, thus creating a spherical capture zone. Groundwater treatment occurs within the well prior to returning to the aquifer. Treatment levels for groundwater discharge to Lake Druid were identified in Chapter 2.0, Table 2-2. Several different proprietary designs of this technology are available.

The various versions of this technology can be separated into two general categories: negative pressure systems and positive pressure systems. In the negative pressure system, a blower is used to create a negative pressure within the recirculation well. This draws groundwater up through the bottom screen, into the well, and into a proprietary stripping reactor positioned within the well casing. The stripper is vented to the ambient air. The negative pressure draws air into the stripper, where VOCs in groundwater are volatilized and drawn out of the well by the blower. If necessary, this off-gas stream can be treated. The treated groundwater exits the in-well stripper, and returns to the aquifer by gravity through the upper well screen. A submersible pump can also be used to draw water through the lower screen and pump it through the stripper.

In a positive pressure system, pressurized air is injected into the recirculation well through a diffuser. The air bubbles rise up the water column, inducing groundwater to enter the well through the lower screen (air lift pumping). As the air-water mixture rises through the well casing, VOCs transfer from the groundwater to the air bubbles. A deflector plate separates the air-water mixture, allowing the air and VOC vapors to be drawn out of the well by a vacuum blower. If necessary, this off-gas stream can be treated. The treated groundwater returns to the aquifer by gravity through the upper well screen.

Both types of recirculation wells return groundwater to the aquifer without extraction. This eliminates the need to consider water disposal options. No drawdown occurs, eliminating the possibility of wetland dewatering and saline intrusion. Groundwater in the spherical treatment cell undergoes several stripping cycles, dependent on the recirculation flow rate within the well and the rate that groundwater enters the cell due to the existing natural gradient. This allows low treatment levels to be achieved within and downgradient of the recirculation cell. The vertical component of the recirculating water can also be very effective at flushing areas where contaminants may be concentrated, accelerating cleanups compared to conventional groundwater extraction, and reducing the likelihood of concentration rebound after system shutdown.

3.1.4.3 **Bioremediation Treatment Technologies** Bioremediation of groundwater is the process of enhancing natural bacterial biodegradation of organic contaminants. This is accomplished by introducing nutrients to stimulate bacterial growth and the speed of biodegradation of organic compounds. Bioremediation can be applied using aerobic (oxygen-rich) conditions or anaerobic (oxygen-poor) conditions.

PCE, TCE and cis-DCE have been shown to biodegrade under anaerobic conditions, but PCE is resistant to degradation under aerobic conditions. Less chlorinated compounds such as TCE and cis-DCE can be degraded under either anaerobic conditions or under aerobic conditions. Aerobic biodegradation of TCE and cis-DCE can be accomplished by a type of aerobic bacteria known as methanotrophs or methane-utilizing bacteria.

Generally, anaerobic degradation of highly chlorinated VOCs, such as PCE, produces TCE, cis-DCE, and VC over time through a process called reductive dechlorination. Complete anaerobic transformation of these compounds results in the production of ethene and ethane which are nonchlorinated and nontoxic end-products. However, in anaerobic degradation of chlorinated VOCs, the rate-limiting factor is the final step where VC is transformed to ethene. If an anaerobic *in situ* treatment system can be implemented such that there is sufficient residence time within a biologically active zone to completely dechlorinate the VOCs, then an anaerobic process could be used for remediation. However, if the dechlorination process is incomplete and biodegradation intermediates such as cis-DCE and VC remain, a second (aerobic-methanotrophic) biological process can be used to rapidly oxidize the remaining intermediate products. Aerobic-methanotrophic biodegradation of these intermediates results in the production of carbon dioxide and water as the final end-products.

The presence of TCE and cis-DCE in groundwater at OU 4 implies that natural anaerobic biodegradation of PCE is already occurring *in situ*. However, concentrations of VOCs in Lake Druid indicate that this degradation is neither complete nor rapid enough to meet regulatory standards. The following approaches could potentially be implemented to increase the rate of natural biodegradation of organic compounds at OU 4:

- Enhance the rate and extent of anaerobic biodegradation by injecting nutrients (such as nitrogen and phosphate) and an additional carbon source (such as lactic acid).

- If monitoring demonstrated that complete degradation was still not occurring, consider establishing aerobic conditions in the downgradient portion of the plume to complete biodegradation of chlorinated VOCs. This would be accomplished by injecting hydrogen peroxide (oxygen source) and methane, if required.

This sequential "two-zone *in situ* bioremediation" technology would be considered innovative. Because of the variability of natural microbial processes, laboratory-scale biodegradation testing may be required to evaluate the microbial conditions present in site groundwater, establish suitable amendment (nutrients, carbon sources, hydrogen peroxide, and methane) concentrations, and identify any factors that may inhibit microbial growth. An additional pilot-scale phase would then be required to demonstrate the effectiveness of this technology under the actual field conditions at OU 4.

3.1.4.4 Permeable Reactive Walls A permeable reactive wall is an *in situ* wall constructed of zero-valent iron (or other zero-valent metal) material. The wall is installed in a location to intercept contaminated groundwater. As contaminated groundwater passes through the wall under natural groundwater flow conditions, the contaminants are removed through chemical and physical processes. This technology relies on the thermodynamic instability of carbon atoms in halogenated organic compounds, such as PCE and TCE, in a reducing environment, thus causing iron in the permeable reactive wall to be oxidized while PCE and TCE are reduced. Once these chemicals have been reduced, degradation of the chemicals to ethenes and ethanes occurs. This technology is patented by the University of Waterloo of Ontario, Canada.

If this technology were implemented at OU 4, a bench-scale study would have to be performed. In addition, fate and transport modeling would be required to predict the fate of organic and inorganic chemicals in groundwater as it discharges to Lake Druid. This modeling would attempt to predict if any adverse effects would occur. Installation of a permeable reactive wall at OU 4, where the confining unit is approximately 60 feet bls, would also likely require complex hydraulic modeling.

3.1.4.5 ***In Situ* Chemical Oxidation** *In situ* chemical oxidation requires the injection of proprietary liquid chemical formulations into the contaminated portion of the aquifer. The reaction chemistry is related to the Fenton's Reaction, where hydrogen peroxide reacts with ferrous ion to produce the hydroxyl radical, a powerful oxidizer. The hydroxyl radical progressively reacts with organic compounds to produce carbon dioxide and water.

If this technology were implemented at OU 4, a bench- and pilot-scale test would be necessary.

3.1.4.6 **Screening of *In Situ* Treatment Technologies** Further evaluation of the following *in situ* treatment technologies is not included in this FFS for various reasons.

Biroemediation would require laboratory- and bench-scale biodegradation testing to evaluate effectiveness given the variability of natural microbial processes. These tests would also be required to evaluate the microbial conditions present at OU 4, as well as the limiting factors that may inhibit microbial growth and contaminant degradation. Additionally, hydraulic control of the contaminated portion of the aquifer may be required.

Permeable reactive walls, once installed, offer no treatment flexibility. OU 4 must be more completely characterized and cleanup levels established before the portion of the aquifer that must be funneled through the wall can be specified. Also, although laboratory tests have been conducted to simulate over 20 years of use, and the results indicate that the chemical activity of the iron material was maintained, the first full-scale implementation of this technology has been in place for only 4 years. Therefore, the long-term effectiveness of the wall has not been field-verified. Also, precipitates or films may form on the reactive materials, and although they do not appear to inhibit the rate of the degradation reaction in laboratory studies, they could limit the hydraulic lifetime of the wall and require intensive operation and maintenance (i.e., flushing).

In situ chemical oxidation is not a continuous process, but instead is applied as needed to the entire aquifer where contaminants are present above action levels. This requires thorough characterization of the plume and/or control of the source area to avoid repeated applications.

Given the aforementioned statement, the air sparging and recirculation/*in situ* well stripping, *in situ* treatment technologies will be evaluated in this FFS.

__3.2 DEVELOPMENT OF ALTERNATIVES__. Three technologies passed the screening step in the previous section, and therefore, three remedial alternatives were developed for the OU 4 FFS. These alternatives include the following:

Alternative 1: Groundwater Extraction and Treatment with Discharge to the Orlando STP

- groundwater extraction via two wells
- pretreatment onsite using air stripping technology
- discharge to the Orlando STP for further treatment

Alternative 2: *In Situ* Treatment via Air Sparging

- installation of air sparging wells
- treatment of groundwater *in situ* via volatilization

Alternative 3: *In Situ* Treatment via In-Well Air Stripping

- installation of in-well stripping wells
- treatment of groundwater *in situ* via air stripping

These alternatives are described and evaluated in detail in Chapter 4.0.

4.0 DETAILED ANALYSIS OF SELECT ALTERNATIVES

This chapter presents the detailed analyses of alternatives for the OU 4 IRA at NTC, Orlando. A detailed analysis is performed to provide decision makers with sufficient information to select the appropriate remedial alternative for the IRA for OU 4. The detailed evaluation of remedial alternatives in this chapter includes the following:

- a detailed description of the alternative, emphasizing the applications of the technology or actions proposed for the alternative; and

- a detailed analysis of the alternative against several criteria.

The detailed analysis provided in this FFS presents the evaluation of the following criteria:

- overall protection of human health and the environment;
- compliance with regulatory requirements;
- reduction of toxicity, mobility, and volume of contaminants through treatment;
- implementability;
- long-term effectiveness and permanence;
- effectiveness with duration of operation; and
- economic feasibility (cost).

4.1 DETAILED ANALYSIS FOR ALTERNATIVE 1: GROUNDWATER EXTRACTION AND TREATMENT. This alternative consists of hydraulic control of contaminated groundwater through extraction, treatment via low profile tray air stripping technology, and discharge to the Orlando STP. A description of this alternative is presented in Subsection 4.1.1, and a technical criteria assessment of this alternative is presented in Subsection 4.1.2.

4.1.1 Detailed Description of Alternative 1 This alternative consists of treatment of VOCs in extracted groundwater to treatment levels for discharge to the Orlando STP (see Chapter 2.0). Treatment via low profile forced aeration tray stripping is expected to achieve the treatment levels.

This alternative consists of the following components:

- hydraulic control through groundwater extraction over the portion of the aquifer that provides a direct path for the migration of total VOCs greater than 100 $\mu g/\ell$ to Lake Druid;

- low profile forced aeration tray stripping;

- treated groundwater discharge to the Orlando STP;

- 1-year operational review; and

- groundwater, surface water, sediment, and system monitoring.

A treatment train for this alternative is depicted on a Process Flow Diagram (Figure 4-1).

Hydraulic Control. Hydraulic control of contaminated groundwater will be achieved through the use of a recovery well network. The proposed extraction system will most likely consist of two recovery wells. The extraction system will be positioned upgradient of Lake Druid, within the central portion of the plume, where the greatest mass removal of contaminants in the surficial aquifer can be achieved. This extraction system will provide hydraulic control of the affected aquifer upgradient of the extraction system.

It is recognized that some portion of contaminated surficial aquifer, beyond the point of stagnation of the extraction system, would continue to migrate to the lake. However, the location of the system discussed in this FFS would provide for the greatest mass removal of contaminants from the surficial aquifer.

The location of the extraction system and its corresponding operational parameters would be evaluated during the design to minimize the amount of contaminated groundwater that would continue to migrate to the lake. In the design phase, the location of the extraction system would be reexamined, considering the physical constraints of the site. Additionally, operational parameters, such as pumping rate, would be evaluated by performing other capture zone simulations. By initially increasing the designated pumping rate of the extraction system (or "phasing" the rate), it may be possible to move the point of stagnation closer to the lake, thereby initially capturing a greater portion of the 100 $\mu g/\ell$ contour. In this manner, the amount of contaminated groundwater that would continue to migrate to the lake would be minimized.

Recovery wells will be connected via manifold and conveyance piping to the groundwater treatment system.

Low Profile Forced Aeration Tray Stripping. Treatment levels for discharge to the Orlando STP were provided in Chapter 2.0. Specific local limits (treatment levels) established by the Orlando STP are provided in Chapter 2.0. The most applicable of these limits is that for toxic organic parameters (less than 10 $\mu g/\ell$ per toxic constituent). As presented in Chapter 2.0, TCE, PCE, and cis-DCE are the only chemicals that require pretreatment to ensure compliance with the STP's local limits.

Based on the percent removal necessary for these contaminants (92 to 99.6 percent), it is estimated that a four-tray low profile forced aeration stripper, as shown on Figure 4-2 with an air flow rate of 900 cubic feet per minute, and a minimum air to water ratio of 67.3 would be effective throughout all the pumping phases in reducing the concentrations of TCE, PCE, and cis-DCE to local limits (i.e., 10 $\mu g/\ell$, each) in extracted groundwater.

Off-Gas Monitoring. At this time, the only VOCs expected to be present in groundwater (based on the analytical data from groundwater samples during the pumping test), and therefore present in the off-gas, are PCE, TCE, and cis-DCE.

FDEP has indicated that air emission requirements for the off-gas of this system will be covered under the FDEP Memorandum dated May 17, 1996, regarding revised guidance on air emissions. The guidance indicates (1) the emission source must be temporary in nature (operated less than 5 years) and (2) air emissions must

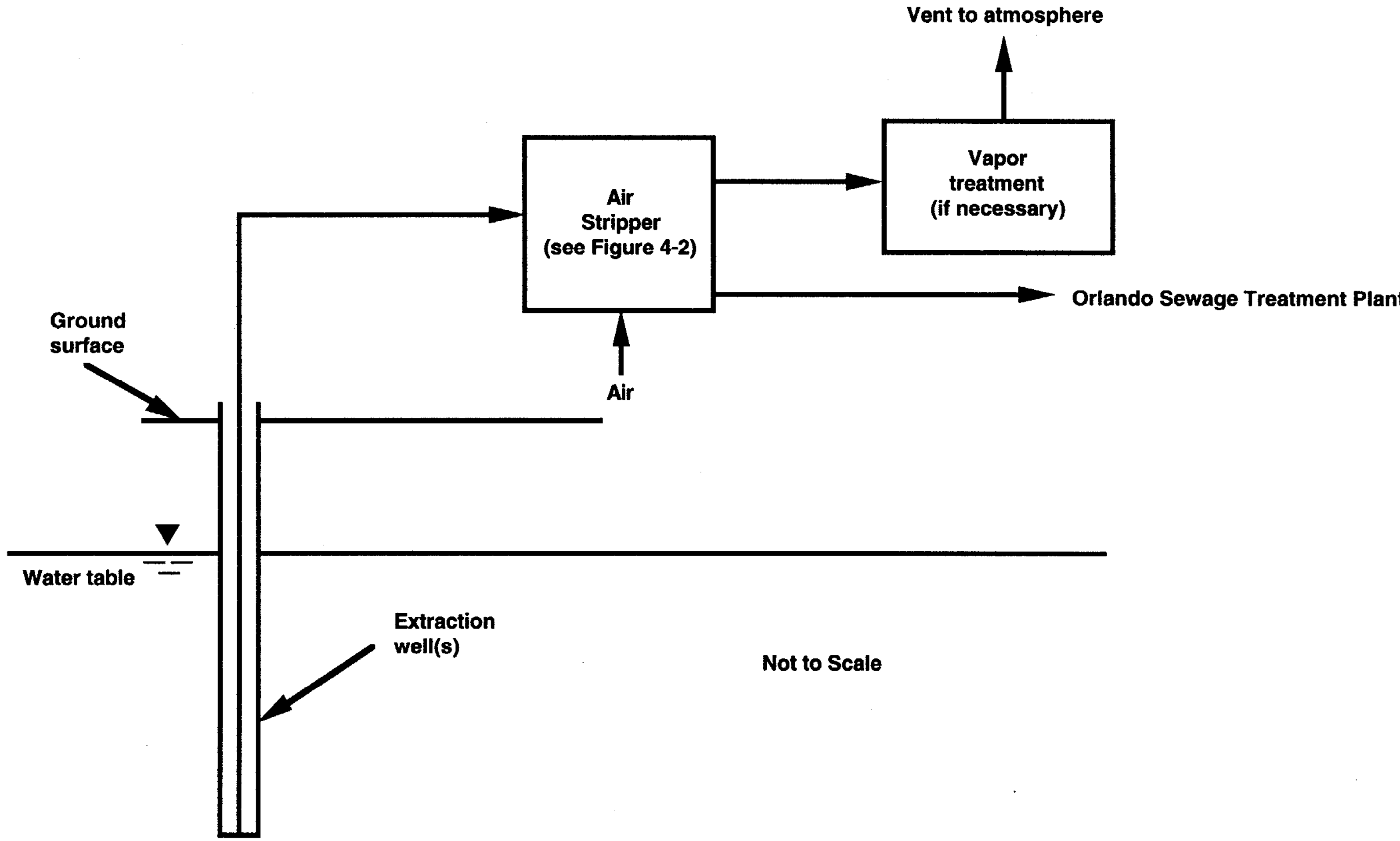

FIGURE 4-1
TREATMENT PROCESS TRAIN,
ALTERNATIVE 1: *EX SITU* AIR STRIPPING

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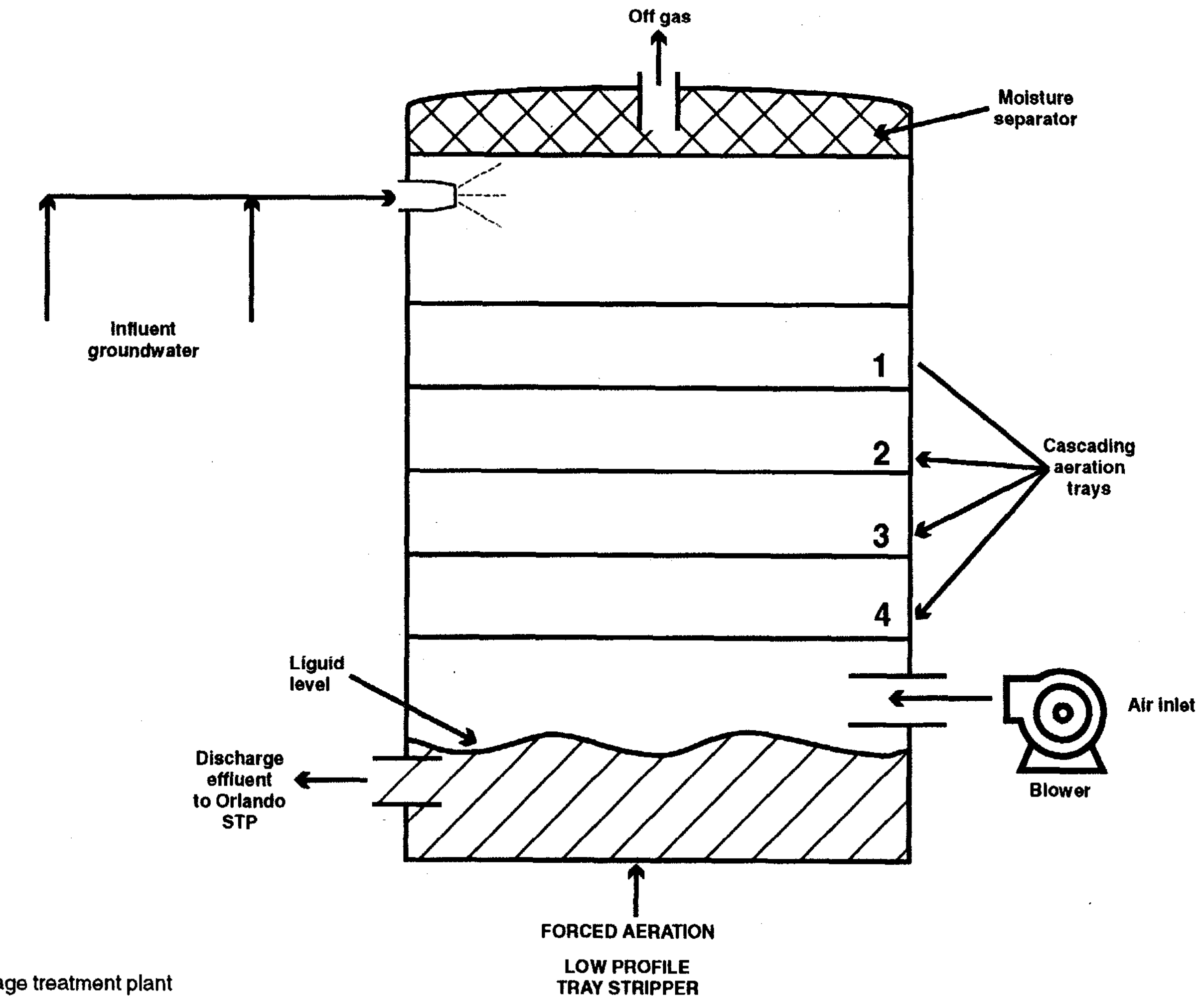
ORLANDO, FLORIDA

8545-73 FIG 4-1 201497MAW



NOTE:
STP = Sewage treatment plant

FIGURE 4-2
SCHEMATIC OF AIR STRIPPER, ALTERNATIVE 1

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G:\USERS\DESIGN\MWTEMP\ORLANDO\8545-73 FIG4-2 021397MAW not exceed 15 pounds per day of total VOCs for treatment of off-gases to be avoided. Therefore, because of the duration of the IRA and the results of the preliminary off-gas emission calculations, off-treatment, along with a formal air permit, is not expected. FDEP has indicated that their approval on the final design will serve as the air permit certification. Preliminary emissions calculations and a copy of the FDEP memorandum are included in Appendix E.

However, samples of organic vapors from the air stripper would be collected and analyzed for VOCs on a regular basis. In this manner, it is possible to identify whether or not off-gas treatment would become necessary. If treatment of the off-gas were to become necessary, vapor-phase GAC could be used to treat VOCs in accordance with action-specific ARARs for air treatment prior to discharge. At least two GAC canisters, connected in series, would be installed at the exhaust from the air stripper. A stack would then be installed after the second GAC canister to adequately disperse the treated exhaust.

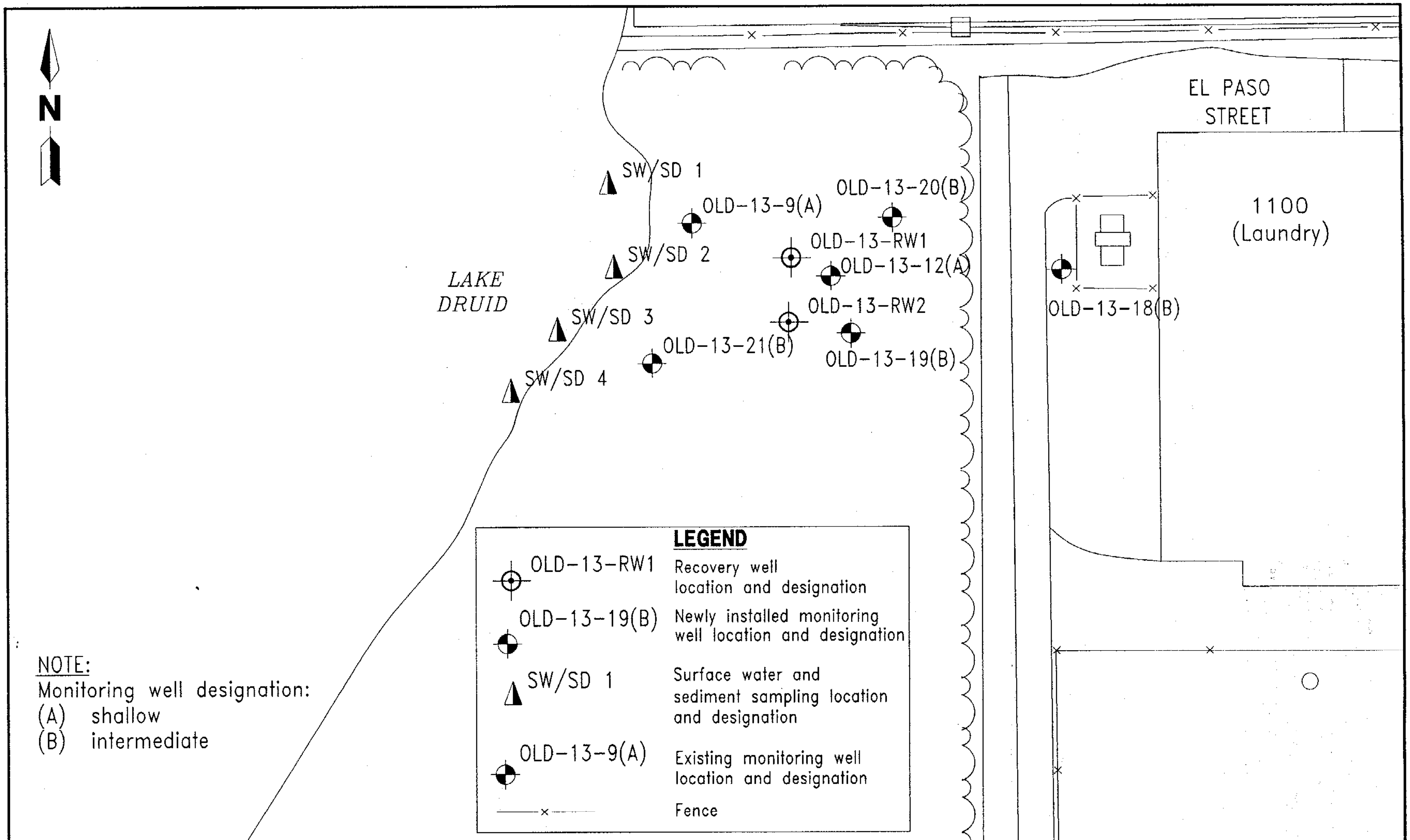
Treated Groundwater Discharge. As described above, treated groundwater from the low profile tray air stripper would be discharged to the Orlando STP. This discharge would adhere to all general prohibitions (i.e., the introduction of contaminants to the STP would not cause interference with the operation of the STP, and would not pass through the system) and specific prohibitions (i.e., would not create a fire or explosion hazard in the sewer or STP, would not cause corrosive damage to the STP, and would not obstruct the flow of water to the STP) of the Clean Water Act (see Chapter 2.0).

Other local limits established by the STP include operating permit requirements. These requirements establish limits on water quality parameters, such as biochemical oxygen demand, pH, and total suspended solids (TSS). While it is anticipated that treatment of extracted water for these parameters is not necessary, effluent from the air stripper would be monitored for these parameters to ensure compliance.

Groundwater, Surface Water, Sediment, and System Monitoring. Monitoring of groundwater, surface water, sediment, the influent and effluent to the treatment system, and off-gas of the air stripper is proposed on a weekly basis for the first month, then monthly for the next 3 months, and then quarterly until the end of the anticipated operational period for the system (i.e., 1 year).

All samples collected during the monitoring program would be analyzed for target compound list (TCL) analytical parameters. Additional parameters may be added, as necessary, and would be based on data needs for the overall RI/FS. Data would be used to evaluate the migration of contaminated groundwater and to assess whether or not contaminant concentrations in surface water and sediment samples from the lake were decreasing. Data would be summarized and managed on a quarterly basis for use in the overall RI/FS.

For the purpose of this FFS, it was assumed that monitoring will consist of collecting samples for laboratory analysis from six groundwater monitoring wells, four surface water and sediment (SW/SD) locations, and from the treatment system's influent and effluent. A total of 16 samples (6 wells, 4 SW/SD, 2 system, and 4 quality control) would be submitted for analysis. Also, one vapor sample would be collected from the off-gas stream of the air stripper and would be analyzed for VOCs. Locations of existing and proposed new wells and SW/SD sampling locations are shown on Figure 4-3. These locations were chosen to



0 50 100
SCALE: 1 INCH = 100 FEET

FIGURE 4-3
SITE MONITORING LOCATION PLAN

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monitor the size of the capture zone, constituent concentrations within the contaminated groundwater area, and effects of hydraulic control on contamination within Lake Druid over time.

In addition to these monitoring activities, the effectiveness of the treatment system and the operation of the low profile tray stripper would also be monitored on a continual basis. Proposed monitoring would include influent and effluent sampling and analysis, liquid and air flow measurements, and other process monitoring requirements.

Sampling locations, laboratory analyses, performance monitoring, and methodology would be detailed in the design documents for the OU 4 IRA.

4.1.2 Technical Criteria Assessment

Overall Protection of Human Health and the Environment. An evaluation of how this alternative reduces human health and environmental risk over baseline conditions cannot be completed at this time (February 1997) because a baseline risk assessment has not yet been completed for OU 4. However, by implementing this alternative, hydraulic control over the portion of the aquifer with total VOCs greater than 100 $\mu g/\ell$ should be obtained. During implementation of this alternative, groundwater containing VOCs and other contaminants would be extracted, thus reducing the mass of contaminants available for discharge to Lake Druid. VOCs in the extracted groundwater would be reduced through treatment via air stripping, with further treatment provided by the Orlando STP.

By implementing this alternative, no adverse short-term or cross-media effects are anticipated.

Compliance with ARARs. This alternative's compliance with ARARs identified in Chapter 2.0 is presented in Table 4-1.

Long-Term Effectiveness and Permanence. Although this FFS was prepared for the OU 4 IRA, this alternative does offer a long-term and permanent remedy for groundwater remediation, without relying on natural transformation processes. Extraction of groundwater removes contaminated groundwater within the capture zone of the extraction wells, thus reducing the available mass of VOCs and other contaminants in groundwater that eventually discharge into Lake Druid. Pretreatment of extracted groundwater via air stripping and further treatment at the Orlando STP will reduce VOC and other contaminant concentrations in extracted groundwater.

Implementing this alternative does not directly address other contaminated media at the site. However, the overall RI/FS for this site is scheduled to begin in the spring of 1997. The overall RI/FS will address these other media.

Groundwater, surface water, and sediment monitoring would provide a means of evaluating the concentrations of contaminants in these media over the IRA timeframe (i.e., 1 year), and would provide a means of evaluating the effectiveness of the alternative. All controls proposed in this alternative are considered reliable.

Table 4-1
Federal and State Regulatory Requirements *Ex Situ* Air Stripping Alternative

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Name and Regulatory Citation	Description	Consideration in the Corrective Action Process
Clean Air Act Regulations, National Emission Standards for Hazardous Air Pollutants [40 CFR Part 61]	Regulations contain emission standards and monitoring requirements for hazardous air pollutants that are likely to cause an increase in mortality or serious illnesses to humans.	TCE, PCE, DCE, cis-DCE, and VC are considered "hazardous air pollutants". Although NESHAP don't generally apply to remedial sites because these sites don't have the sources that are regulated, the emission standards for the Perchloroethylene Dry-Cleaning Industry could be used as "to be considered" guidance.
Clean Water Act (CWA) Regulations, General Pretreatment Regulations for Existing and New Sources of Pollution [40 CFR Part 403]	Establishes pretreatment standards for the control of pollutants discharged into POTW by industrial and nondomestic sources. Imposes general prohibitions and specific prohibitions on indirect discharges that apply directly to all nondomestic sources and are implemented through the development and enforcement of local limits.	If the discharge is sent from the groundwater treatment system to a POTW, pretreatment would need to be conducted in accordance with these requirements. "Local limitations" must be complied with.
CWA Regulations, Water Quality Standards [40 CFR Part 131]	Establishes ambient water quality criteria (AWQC). AWQC are nonenforceable, ecological, and health-based criteria for carcinogenic and noncarcinogenic compounds and are used by states, in conjunction with a designated use for the surface water body, to establish water quality standards.	In the absence of Florida water quality standards that are specific to the pollutants of concern, these standards would apply.
Occupational Safety and Health Act (OSHA) Regulations, Occupational Safety and Health Standards [29 CFR Part 1910]	Provides fundamental requirements to ensure worker health and safety at hazardous waste sites.	Corrective action work must be conducted in accordance with these requirements.
OSHA Regulations, Toxic and Hazardous Substances Regulations [29 CFR Part 1910, Subpart Z]	Establishes permissible exposure limits for workplace exposure to a specific listing of chemicals.	Standards are applicable for worker exposure to OSHA hazardous chemicals during corrective action.
OSHA Regulations, Recording and Reporting Occupational Injuries and Illnesses [29 CFR Part 1904]	Provides recordkeeping and reporting requirements for enforcement of the Act and for developing information regarding the causes and prevention of occupational accidents and illnesses.	Requires the onsite maintenance of records of injuries and illnesses and requires reporting to OSHA of serious illnesses.
Florida Environmental Resource Permits [Chapter 62-341, FAC]	Section 341.475 provides criteria for obtaining a "general permit for minor activities" for dredging or filling of less than 100 square feet of wetlands or other surface waters.	This type of permit may be required for installing the air stripping equipment in the lake shoreline.
Florida Surface Water Quality Standards [Chapter 62-302, FAC]	The rule differentiates surface water into five classes based on designated uses and establishes ambient water quality standards (called, Florida Water Quality Standards) for listed pollutants. Because Florida criteria are specifically tailored to site circumstances, they should be used to establish cleanup levels rather than the Federal AWQC.	Lake Druid is classified as surface water III. The AWQS would be relevant in determining the levels of pretreatment necessary before the groundwater may be discharged to surface water. Florida has criteria for TCE, PCE and DCE but not VC or cis-DCE, therefore, Federal criteria would be used.

See notes at end of table.

Table 4-1 (Continued)
Federal and State Regulatory Requirements *Ex Situ* Air Stripping Alternative

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Name and Regulatory Citation	Description	Consideration in the Corrective Action Process
Florida Groundwater Classes, Standards and Exemptions [Chapter 62-520, FAC]	The rule classifies the groundwaters of the state into five classes and establishes minimum "free from" criteria. The rule also specifies that classes I and II must meet the primary and secondary drinking water standards listed in Chapter 62-550, FAC.	The groundwater at OU 4 is Class II. Therefore, the groundwater must be treated to meet the primary and secondary drinking water standards listed in Chapter 62-550, FAC.
Florida Drinking Water Standards [Chapter 62-550, FAC]	Rule adopts Federal primary and secondary drinking water standards.	Because the groundwater at OU4 is class II, these standards should be considered when establishing cleanup levels.
Florida Pretreatment Requirements for Existing and New Sources of Pollution [Chapter 62-625, FAC]	Establishes the responsibilities of various bodies to implement pretreatment standards to control pollutants that pass through or interfere with treatment processes in domestic wastewater facilities.	If groundwater wastes are discharged to a POTW, these requirements would apply.
Florida Water Quality Based Effluent Limitations [Chapter 62-650, FAC]	Establishes NPDES permit limitations for effluents that must be met before the effluents may be discharged to navigable waters.	These requirements would apply if discharging groundwater to surface water.
Florida Rules on Permits [Chapter 62-4, FAC]	Provides permitting requirements for water pollution sources and air emission units.	A permit for the air stripper off-gas would be required unless the project qualifies as an insignificant source under the exemptions in 62-4.040, FAC.
Groundwater Guidance Concentrations, Bureau of Groundwater Protection, June 1994.	Establishes maximum concentration levels for groundwater contaminants in the State of Florida. Groundwater with concentrations less than the listed values are considered "free from" contamination.	The values in this guidance should be considered when determining cleanup levels for groundwater.
Approach to Sediment Quality in Florida Coastal Waters, 1995.	These guidelines should be considered when evaluating potential biological harm posed by contaminated sediments in Florida coastal waters.	These guidelines may be used in assessing the sediment quality in Lake Druid after air stripping has begun.
Soil Cleanup Goals for Florida, September 1995.	Provides guidance for soil cleanup levels which can be developed on a site-by-site basis using the calculations found in Appendix B of the documents.	These guidelines aid in determining leachability-based cleanup goals for soil.

Notes: CFR = Code of Federal Regulations.
TCE = trichloroethene.
PCE = tetrachloroethene.
DCE = 1,1-dichloroethene.
cis-DCE = cis-1,2-dichloroethene.
VC = vinyl chloride.
NESHAP = National Emission Standards for Hazardous Air Pollutants.
POTW = publicly owned treatment works.
FAC = Florida Administrative Code
NPDES = National Pollutant Discharge Elimination System.

Reduction of Toxicity, Mobility, and Volume of Contaminants through Treatment. This alternative would permanently reduce the toxicity, mobility, and volume of VOCs and other contaminants in extracted groundwater. VOCs will be treated via air stripping, and the off-gas from the air stripper would be monitored to determine whether or not collection and treatment via GAC is necessary. The treated groundwater would be discharged to the Orlando STP for further treatment of VOCs and treatment of other contaminants. Predicted removal rates and treatment levels for this alternative were discussed in Chapter 2.0, and would be achieved under this alternative.

Short-Term Effectiveness. By implementing this alternative, the migration of groundwater contamination to Lake Druid would be affected immediately. Contaminated groundwater would be extracted, thereby mitigating further migration from the "hot zone." No other additional short-term effects are anticipated. Installing an extraction well, treating the groundwater, and discharging to the Orlando STP should not pose a significant risk to workers or the community.

Implementability. Construction of the extraction and treatment system is relatively easy to implement and would not pose a threat to workers or the community. Components of the proposed system are readily available (i.e., "off-the-shelf" products).

Cost. The present worth cost of this alternative is presented in Table 4-2. This estimate includes site preparation, installation of the groundwater extraction system, the air stripper, discharge to Orlando STP, system maintenance, and utilities for the duration of system operation (1 year).

Direct costs include site preparation, treatment system costs, and an air stripper. Direct costs for performance evaluation items for the alternative are items such as installing three monitoring wells for the proposed groundwater monitoring program. Total direct costs are estimated to be $102,090, total O&M costs are estimated to be $112,800, total site monitoring costs are estimated to be $43,200, and total reporting costs are estimated to be $5,400. The total cost for this alternative is therefore estimated to be $263,490. Cost basis is included in Appendix F.

4.2 DETAILED ANALYSIS OF ALTERNATIVE 2: *IN SITU* TREATMENT VIA AIR SPARGING

This alternative would provide for treatment of VOCs in groundwater via *in situ* air sparging. A description of this alternative is presented in Subsection 4.2.1, and a technical criteria assessment of this alternative is presented in Subsection 4.2.2.

4.2.1 Detailed Description of Alternative 2 Air sparging is used to remove VOCs from groundwater without extracting the water. Air is injected into the saturated zone to volatilize organic compounds. As air moves up through the aquifer, contaminants partition into the gas phase and are then extracted as organic vapors from the vadose zone or allowed to escape through the vadose zone into the atmosphere. Injected air can also stimulate microbial degradation of contaminants if the required microbes thrive in aerobic conditions (Johnson, et. al., 1993).

Air sparging is typically used in combination with SVE to control off-gas generated by organic compound volatilization. SVE uses negative pressure to collect extracted vapors. Typically, vapor extraction wells or trenches are

Table 4-2
Estimated Cost for *Ex Situ* Air Stripping

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Item Description	Quantity	Total Cost ($)
CORRECTIVE ACTION IMPLEMENTATION		
Planning & Procurement[1]		14,000.00
Installation Services[2]		
• Recovery Well	1	12,190.00
• Development	12 hr	1,500.00
• Disposal of Development Fluids	5,000 gal	1,500.00
• Trenching and Piping	200 ft	600.00
• Well Head Completions and Manifold	2	2,000.00
• Submersible Pumps and Controls	2	3,200.00
• Other IDW		2,000.00
• Low Profile Air Stripping Equipment w/ control panel, controls,	1	20,900.00
• Miscellaneous Piping and Valves		1,000.00
• Electrical Service Wiring		4,000.00
• Startup and Optimization		4,500.00
• Enclosure and Concrete Pad		16,500.00
Surveying		500.00
Permitting		
• Air Discharge		
Permit Preparation		1,500.00
• Water		
Permit Preparation		500.00
Construction Management		
• Labor		15,700.00
Subtotal		**102,090.00**

See notes at end of table.

Table 4-2 (Continued)
Estimated Cost for *Ex Situ* Air Stripping

Focused Feasibility Study
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Item Description	Quantity	Total Cost ($)
OPERATION AND MAINTENANCE (per month)		
Professional Services		1,600.00
Utilities		7,725.00
Equipment and Supplies		75.00
Subtotal (per month)		9,400.00
Subtotal (project life)		**112,800.00**
SITE MONITORING[3] (per month)		
Professional Services		2,700.00
Analytical		900.00
Subtotal (per month)		3,600.00
Subtotal (project life)		**43,200.00**
REPORTING[3] (per month)		
Professional Services (Labor)		450.00
Subtotal (per month)		450.00
Subtotal (project life)		**5,400.00**
	TOTAL:	**263,490.00**

[1] Subcontractor and equipment.
[2] Prices include equipment, material, and installation.
[3] Six times over the life of the project.

Notes: Project life is assumed to be 1 year.
No travel costs associated with Operations and Maintenance or Site Monitoring activities.
hr = hour.
gal = gallon.
ft = feet.
IDW = investigation-derived wastes.

installed above the water table, in a configuration to capture vapors generated from air sparging. However, at OU 4, the thickness of the unsaturated zone is less than 1.5 feet (in some places), and therefore the effectiveness of SVE in a limited vadose zone is questionable. Additionally, combined air sparging with SVE may initially cause the water table to rise and possibly breach the ground surface, drawing water into the SVE system.

The following components would be included in this alternative:

- pilot-scale study,
- air injection,
- vapor extraction,
- vapor-phase treatment and monitoring (if necessary), and
- groundwater sampling and system monitoring.

A typical air sparging system process train and schematic are depicted on Figures 4-4 and 4-5, respectively.

Pilot Test. Prior to installing an air sparging system at OU 4, a pilot test would be conducted. It is anticipated that the pilot test would include two tests: one for air sparging, and one for SVE. The tests would be necessary to obtain design criteria for the alternative and evaluate the technical feasibility of an air sparging system. Specifically, the pilot test would include:

- estimating the efficiency of removal of VOCs from groundwater;

- evaluating the potential for the water table to mound and the effects of this occurrence;

- estimating VOC emission rates (both with SVE and without);

- predicting and evaluating the path of air flow in the subsurface, including the effects of a hard layer identified approximately 15 feet bls (see Figure 1-6);

- evaluating changes in aquifer characteristics (the effective porosity to water flow is reduced when air is introduced to the subsurface, or when there is a mixture of liquid and gas phases in the aquifer, and this may reduce the hydraulic conductivity [Johnson, et. al., 1993]); and

- identifying the number of sparge wells and SVE wells that are necessary (i.e., determining the radius of influence of individual air sparging wells).

Air Sparging System: Air Injection and Vapor Extraction. The conceptual design of this alternative (for cost estimating purposes) was based on ABB-ES's experience with pilot-scale tests at a nearby location that contains similar stratigraphy and contaminants. This design was also based on air sparging guidance documents (Wisconsin DNR, 1993a and 1993b). It is anticipated that an observational approach (i.e., install the system, observe conditions, and optimize operation of the system without performing extensive bench- and pilot-scale studies before installation) would be used to continually modify this design based on system performance.

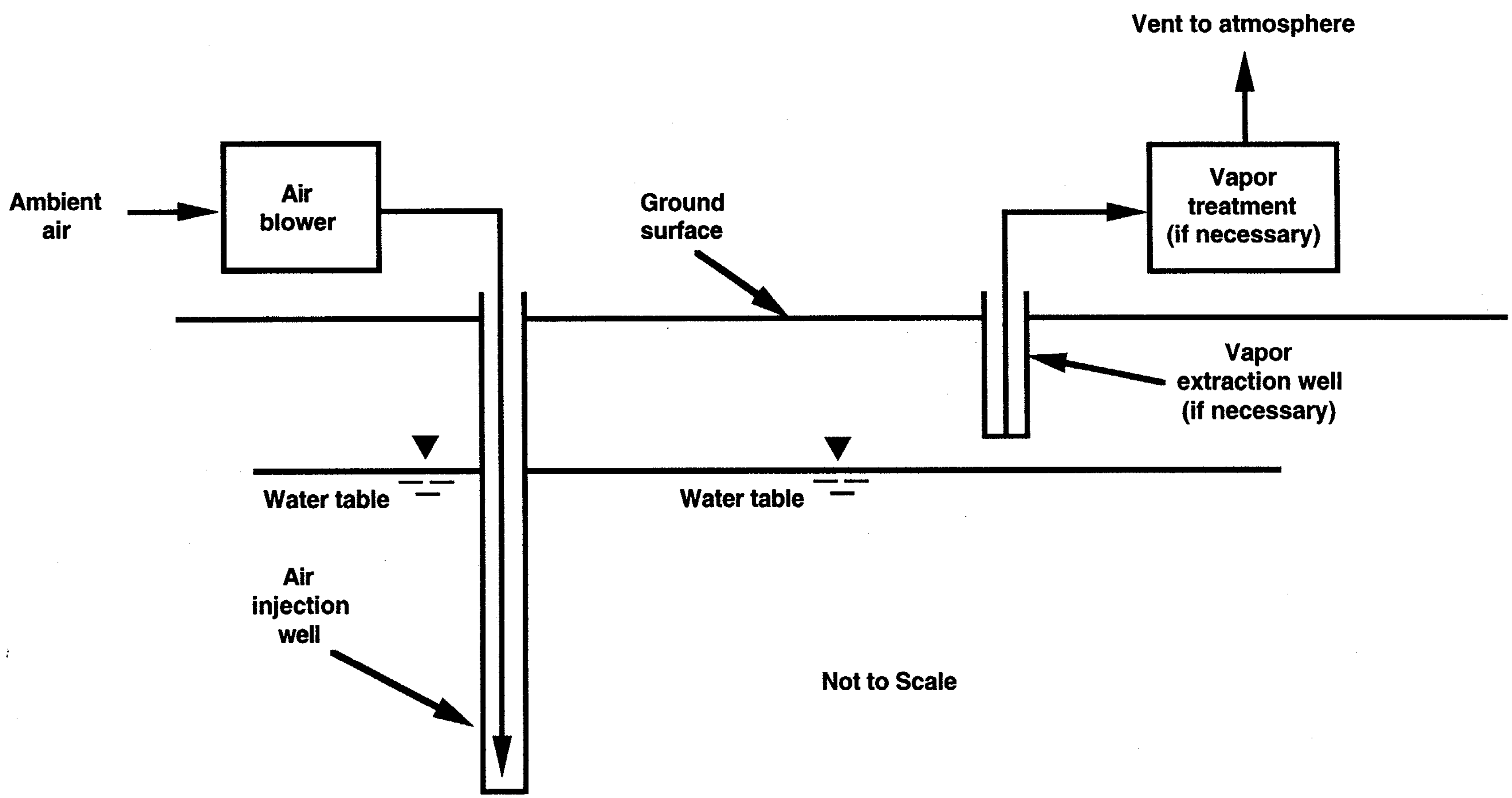

FIGURE 4-4
TREATMENT PROCESS TRAIN,
ALTERNATIVE 2: *IN SITU* AIR SPARGING

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8545-73 FIG 4-4 050897MAW

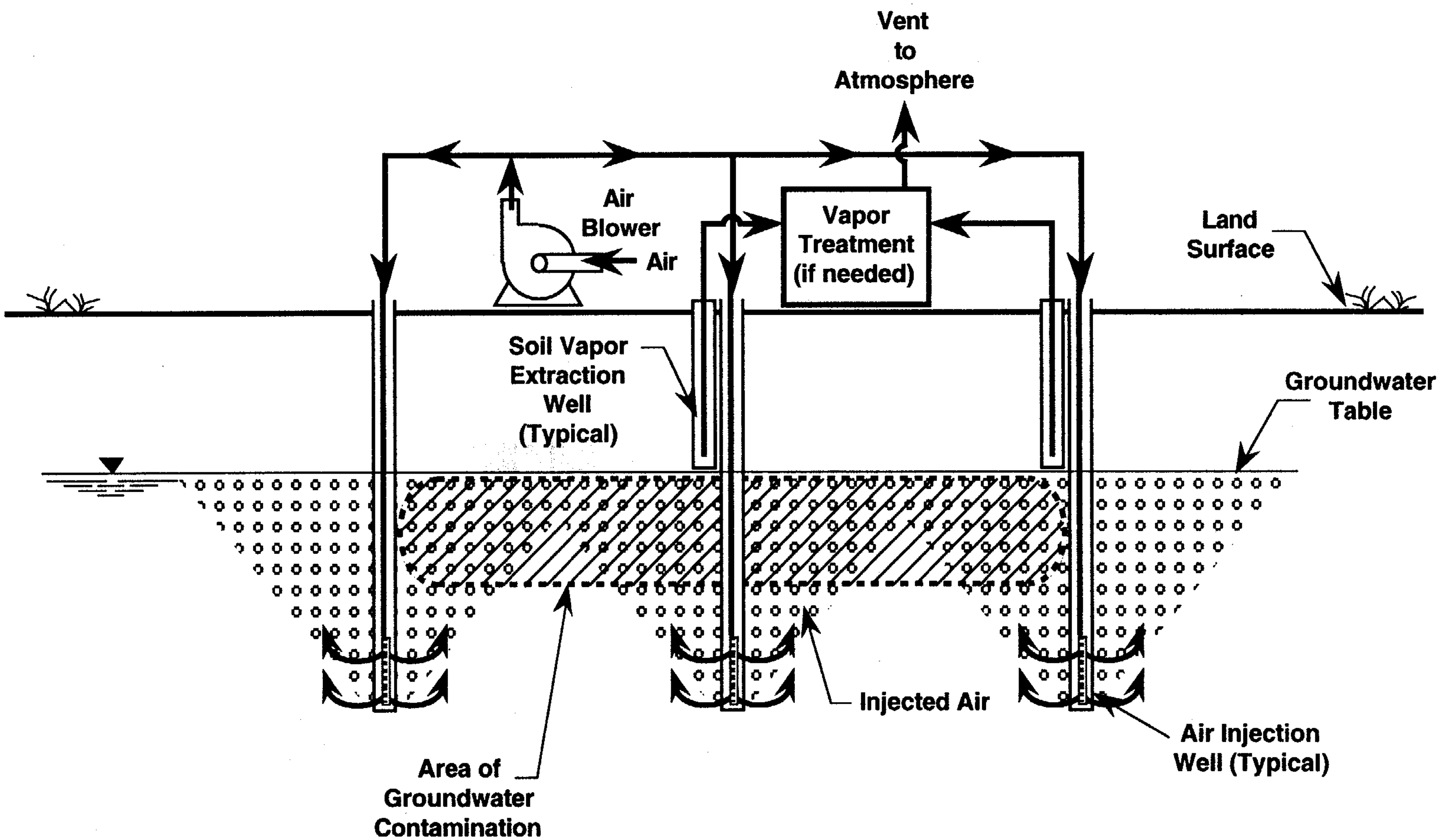

FIGURE 4-5
SCHEMATIC OF AIR SPARGING,
ALTERNATIVE 2

FOCUSED FEASIBILITY STUDY
OPERABLE UNIT 4

NAVAL TRAINING CENTER
ORLANDO, FLORIDA

8545-73 FIG 4-5 050897MAW

It is anticipated that an air sparging system for OU 4 could be installed to a depth of 40 feet (or the depth of contamination). Either vertical or horizontal air injection wells could be installed. At this time (until a pilot test is conducted), the effect of the presence of the hard layer (located at 15 feet bls) is unknown. This evaluation assumes that injected air would migrate to the surface through the hard layer (see Figure 1-6). However, the possibility exists that the hard layer could impede the migration of air to the surface, and may force air to migrate horizontally.

If vertical wells were installed, it is estimated that 13 air injection wells on 20-foot spacing would be needed for implementation of air sparging at OU 4. The wells would be constructed with 2-inch inner diameter (ID), schedule 40, polyvinyl chloride (PVC), with a 5-foot screen at the bottom of each well.

Alternatively, horizontal wells could be used. The horizontal well would be constructed with 2-inch ID, schedule 80, PVC, with intermittent slots. The slot intervals would be determined after analysis of the pilot test data.

Vapor-Phase Treatment and Monitoring. If SVE were necessary and feasible (to be determined by the pilot test), organic vapors in the off-gas collected from the SVE system may have to be removed prior to discharge to comply with applicable regulations. Vapor-phase GAC would most likely be sufficient to remove the types of chlorinated compounds detected at OU 4. It is estimated that two vapor-phase GAC canisters would be sufficient to remove the types of chlorinated compounds detected at OU 4. These canisters would be installed at the discharge end of the regenerative vacuum blower. A stack would then be installed after the second GAC canister to adequately disperse the treated exhaust.

Groundwater Sampling and System Monitoring. Groundwater samples would be collected to evaluate the effectiveness (i.e., percent removal) of the air sparging system. It is estimated that eight samples would be necessary: four upgradient of the air sparging system (two above the hard layer and two below) and four downgradient of the system (again, two above the hard layer and two below). Samples would be analyzed for VOCs. Sampling would occur weekly for the first month, and then monthly for the duration of the operation of the system. In order to accomplish this monitoring program, it is estimated that 6 additional monitoring wells would need to be installed (these wells could, in the long-term, be used for the OU 4 overall RI).

Samples of organic vapors in the SVE system (if SVE were necessary and feasible) would be required to assess the rate of gas transfer, the effectiveness of vapor-phase treatment, and compliance with air discharge limitations. Again, samples would be analyzed for VOCs. Sampling would occur daily during the first week of implementation, weekly for the first month, and then monthly for the duration of the operation of the system. If SVE were not used for the air sparging system at OU 4, it would still be necessary to monitor the ambient atmosphere in the vicinity of the system (i.e., over the top of the air sparging area) and at the property line to identify whether or not vapors released to the atmosphere are at a level of concern to human health or the environment.

This evaluation assumes that surface water and sediment sample pairs would be collected on a monthly basis from the shoreline of Lake Druid, and analyzed for total VOCs. The analytical results would be reviewed to evaluate whether or not the concentrations of VOCs in the lake were decreasing over time, due to the implementation of air sparging.

If this alternative were implemented for the OU 4 IRA, sampling locations, laboratory analyses, performance monitoring, and methodology would be detailed in the design documents for the OU 4 IRA.

4.2.2 Technical Criteria Assessment

Overall Protection of Human Health and the Environment. An evaluation of how this alternative reduces human health and environmental risk over baseline conditions cannot be completed at this time (February 1997) because a baseline risk assessment has not yet been completed for OU 4. However, by implementing this alternative, reduction of concentrations of VOCs in groundwater should be achieved, thus limiting one migration pathway for VOCs entering Lake Druid. During implementation of this alternative, air would be injected into the subsurface, thus stripping VOCs from groundwater and reducing the mass of contaminants available for discharge to Lake Druid.

Compliance with ARARs. This alternative's compliance with ARARs identified in Chapter 2.0 is presented in Table 4-3.

Long-Term Effectiveness and Permanence. Although this FFS was prepared for the OU 4 IRA, this alternative does offer a long-term and permanent remedy for groundwater remediation. However, there is some doubt concerning the long-term effects of air migration in the subsurface.

Because the transfer of dissolved contaminants from groundwater to air occurs in subsurface conditions and laboratory simulation is difficult, conclusions regarding the path of subsurface air flow are based on limited laboratory-scale studies and field testing systems. Two theories have been proposed to describe the subsurface air flow: air flows in a stream of discrete air bubbles, or air flows in continuous air channels. As air enters the saturated zone, it creates hydraulic voids or "cavitation." These voids can occur in the form of bubbles or channels. The form of cavitation that occurs is primarily a function of grain size, shape, homogeneity, porosity, and other subsurface media characteristics.

Laboratory observations indicate that air flow through porous media, such as coarse sand and gravel (greater than 4 mm in diameter) occurs through air bubbles that rise to the top of the water column. Conversely, air flow through fine media, such as fine sand, silt, and clay (less than 0.75 mm in diameter) occurs through streams or air channels. It is estimated that, given the fine sand present at OU 4, the potential exists for air channels to develop. This is important because the channeling reduces the air contact surface area to groundwater and aquifer material, which reduces the mass transfer of VOCs and oxygen and ultimately may reduce the effectiveness of this technology.

Additionally, the presence of the hard layer raises questions as to where the air bubbles or channels may escape, and the effect this may have on groundwater flow in the area. As far as migration of the air bubbles or channels, some air may migrate through the hard layer. Otherwise, it is possible that air may accumulate below the hard layer and migrate horizontally until it can escape into the vadose zone. If the latter is the case, data from the field investigation have shown that the hard layer is not present near the fence line. Thus the

Table 4-3
Synopsis of Federal and State Regulatory Requirements

Focused Feasibility Study
Operable Unit 4
Naval Training Center
Orlando, Florida

Name and Regulatory Citation	Description	Consideration in the Remedial Action Process
Clean Air Act Ambient Air Quality Standards [40 CFR Part 50]	Provides emission standards for hazardous air pollutants that are likely to cause an increase in mortality or serious illness.	The emission standards and monitoring requirements in this rule are relevant and appropriate to remedial activities that involve the discharge of pollutant to the air and may affect ambient air quality. The State of Florida enforces these requirements throughout the SIP (see 62-272).
OSHA Regulations, Occupational Safety and Health Standards [29 CFR Part 1910, various subparts]	Provide fundamental requirements to ensure worker health and safety at hazardous waste sites.	Corrective action work must be conducted in accordance with these requirements.
OSHA Regulations, Recording and Reporting Occupational Injuries and Illnesses [29 CFR Part 1904]	Provides recordkeeping and reporting requirements for enforcement of the Act and for developing information regarding the causes and prevention of occupational accidents and illnesses.	Requires the onsite maintenance of records of injuries and illnesses and requires reporting to OSHA of serious illnesses.
Florida Ambient Air Quality Standards [Chapter 62-272, FAC]	Establishes ambient air quality standards necessary to protect human health and welfare.	Air sparging activities should meet these standards.
Florida Groundwater Classes, Standards and Exemptions [Chapter 62-520, FAC]	Establishes the groundwater classification system for the State and provides minimum criteria for groundwater. States that groundwater that is class I or II must be treated to meet the primary and secondary standards.	Groundwater at OU 4 is class II, therefore the primary and secondary standards in 62-550, may apply.
Florida Drinking Water Standards [Chapter 62-550, FAC]	Rule adopts Federal primary and secondary drinking water guidelines as enforceable State standards.	These standards should be considered when selecting cleanup level for the groundwater.
Florida Environmental Resource Permits [Chapter 62-341, FAC]	Provides criteria for obtaining a "general permit for minor activities" for dredging or filling of less than 100 square feet of wetlands or other surface waters.	This type of permit may be required for installing the air sparging equipment in the shoreline of the lake.
Florida Surface Water Quality Standards [Chapter 62-302, FAC]	Rule differentiates surface water into five classes based on designated uses and establishes ambient water quality standards (called Florida Water Quality Standards) for listed pollutants. The surface water at OU 4 is class III.	Surface water samples from Lake Druid would be compared to these standards to assess the effectiveness of the air sparging.

See notes at end of table.

Table 4-3 (Continued)
Synopsis of Federal and State Regulatory Requirements

Focused Feasibility Study
Operable Unit 4
Naval Training Center
Orlando, Florida

Name and Regulatory Citation	Description	Consideration in the Remedial Action Process
Groundwater Guidance Concentrations, Bureau of Groundwater Protection, June 1994.	The document establishes maximum concentration levels for groundwater contaminants in the State of Florida. Groundwater with concentrations less than the listed values are considered "free from" contamination.	The values in this guidance should be considered when determining cleanup levels for groundwater.
Approach to the Assessment of Sediment Quality in Florida Coastal Water, 1995.	These guidelines should be considered when evaluating potential biological harm posed by contaminated sediments in Florida coastal waters.	These guidelines may be used for analyzing the Lake Druid sediment quality after air sparging has begun.
Soil Cleanup Goals for Florida, September 1995.	This document provides guidance for soil cleanup levels, which can be developed on a site-by-site basis using the calculations found in Appendix B of the guidance.	These guidelines aid in determining leachability-based cleanup goals for soils.

Notes: CFR = Code of Federal Regulations.
SIP = State Implementation Plan.
OSHA = Occupational Safety and Health Act.
FAC = Florida Administrative Code.

possibility of air migrating to the fence line and then through the vadose zone and into the atmosphere at this location exists; this is a concern because residents in that area would be exposed. Also, air migrating along the hard layer to the fence line could potentially introduce contamination to that area.

Also, it is possible that an air bubble may form beneath the hard layer, thus affecting air flow in the subsurface, and possibly displacing contaminated groundwater, which may introduce contamination into areas not already contaminated.

Reduction of Toxicity, Mobility, and Volume of Contaminants through Treatment. This alternative would reduce the toxicity, mobility, and volume of VOC contaminants in groundwater. This would be accomplished through volatilization of dissolved contaminants.

Short-Term Effectiveness. This alternative would comply with RAOs in the short term because volatilization and gas transfer is a relatively rapid treatment process. When air is injected into the subsurface through a well(s), convection currents form that circulate the groundwater in the vicinity of the well. These currents form due to the density differences between the air-water mixture and the groundwater further away from the well.

One possible short-term effect of this process is that this action may create groundwater upwelling near the air sparging locations. At OU 4, the groundwater table is only approximately 1.5 feet bls (in places), and it is possible that the upwelling effect may present itself as a pool of water on the ground surface. If this occurs, the potential exists for human and ecological receptors to be in direct contact with the contaminated groundwater, and the contamination of soil in that area.

Implementability. Workers installing the sparging system may require Level C personnel protection. Concentrations of VOCs in subsurface soil may warrant this protection; site monitoring would be conducted during installation to determine the appropriate level of protection. Also, the air sparging system would need to be installed in a wetland. Appropriate permits would need to be secured, and minimal disruption of the wetlands would be necessary.

Cost. In order to prepare a cost estimate for implementing air sparging at OU 4, a preliminary configuration of the air sparging system was prepared. This configuration was prepared based on a review of current literature on air sparging. Data from the pilot test should be evaluated to more accurately define the appropriate system configuration. Table 4-4 presents the estimated cost for installation of air sparging at OU 4. The costs provided assume that a horizontal air sparging well would be installed.

Direct costs include a pilot study, site preparation, and treatment system costs. Direct costs for performance evaluation of the alternative include installation of monitoring wells for the proposed groundwater monitoring program. Total direct costs are estimated to be approximately $258,850.00, total O&M costs are estimated to be $24,600.00, total site monitoring costs are estimated to be $50,160.00, and total reporting costs are estimated to be $5,400.00. The total cost for this alternative is therefore estimated to be $339,010. Cost basis is included in Appendix F.

Table 4-4
Estimated Cost for *In Situ* Air Sparging

Focused Feasibility Study
Operable Unit 4
Naval Training Center
Orlando, Florida

Item Description	Quantity	Total Cost ($)
PILOT-SCALE AIR SPARGING TEST AND EVALUATION		
Professional Services[1]		49,900.00
Equipment		6,100.00
Drilling/Analytical		12,000.00
Subtotal:		**68,000.00**
PILOT-SCALE SOIL VAPOR EXTRACTION TEST		
Professional Services[1]		26,500.00
Equipment		4,650.00
Subtotal:		**31,150.00**
CORRECTIVE ACTION IMPLEMENTATION		
Planning and Procurement[2]		10,000.00
Installation Services[3]		
• Air Sparging Wells (Horizontal)	2	69,500.00
• SVE Wells	16	4,800.00
• Monitoring Wells	6	5,900.00
• Drill Cuttings	22 yd^3	7,800.00
• Trenching and Piping	800 ft	2,400.00
• Well Head Completions and Manifolds	20	3,100.00
• Air Compressor w/ Dryer	2	10,000.00
• SVE Unit	1	6,200.00
• Miscellaneous Piping and Valves		1,000.00
• Electrical Service Wiring		3,500.00
• Startup and Optimization		7,000.00
• Enclosure and Concrete Pad		4,000.00
Surveying		1,000.00
Permitting		
• Air Discharge		

See notes at end of table.

Table 4-4 (Continued)
Estimated Cost for *In Situ* Air Sparging

Focused Feasibility Study, Operable Unit 4
Naval Training Center
Orlando, Florida

Item Description	Quantity	Total Cost ($)
Permit Preparation		1,500.00
• Wetland		3,500.00
Permit Preparation		
Construction Management		18,500.00
• Professional Services		**159,700.00**
Subtotal		
OPERATION AND MAINTENANCE (per month)		
Professional Services		1,600.00
Utilities		400.00
Equipment and Supplies		50.00
Subtotal (per month)		2,050.00
Subtotal (project life)		**24,600.00**
SITE MONITORING[3] (per month)		
Professional Services		3,100.00
Analytical		1080.00
Subtotal (per month)		4,180.00
Subtotal (project life)		50,160.00
REPORTING[3] (per month)		
Professional Services (Labor)		450.00
Subtotal (per month)		450.00
Subtotal (project life)		**5,400.00**
	TOTAL:	**339,010.00**

[1] Includes: Planning; Procurement; Setup/Installation; Test; Breakdown; and Data Evaluation
[2] Subcontractor and equipment.
[3] Prices include equipment, material, and installation.
[4] Monitoring wells Installed for Site Activities
[5] Twelve times over the life of the project, includes eight groundwater samples.
[6] Six times over the life of the project.

Notes: Project life is assumed to be 1 year.
No travel costs associated with Operations and Maintenance or Site Monitoring activities.
No vapor phase treatment estimated for SVE discharge.
yd^3 = cubic yard.
ft = feet.
SVE = soil vapor extraction.

4.3 DETAILED ANALYSIS FOR ALTERNATIVE 3: *IN SITU* TREATMENT VIA IN-WELL AIR STRIPPING. This alternative consists of hydraulic control by intercepting contaminated groundwater, via recirculation well technology, treatment within the well by aeration, and discharge back to the aquifer, without water being pumped above ground surface. A description of this alternative is presented in Subsection 4.3.1, and a technical criteria assessment of this alternative is presented in Subsection 4.3.2.

4.3.1 Detailed Description of Alternative 3 This alternative consists of *in situ* treatment of groundwater VOCs using recirculation well technology with *in situ* (in well) stripping to treat VOCs above action levels. This alternative consists of the following components:

- hydraulic control through interception of the portion of the aquifer that provides a direct path for the migration of total VOCs greater than 100 $\mu g/\ell$ to Lake Druid;
- stripping of groundwater traveling through the recirculation well; and
- groundwater, surface water, sediment, and system monitoring.

A treatment train for this alternative is depicted on Figure 4-6.

Hydraulic Control. Hydraulic control of contaminated groundwater will be achieved through the use of the recirculation well technology, which creates a circulation sphere within the affected portion of the surficial aquifer. Groundwater enters through the lower part of the recirculation well, travels up through the well, and exits near the top, thus creating a spherical capture zone (Figure 4-7).

The proposed recirculation and *in situ* stripping treatment system will most likely consist of two recirculation treatment systems. The systems will be positioned upgradient of Lake Druid, within the central portion of the plume, where the greatest mass removal of contaminants in the surficial aquifer can be achieved. The systems will intercept VOC-contaminated groundwater with total VOC concentrations greater than 100 $\mu g/\ell$ discharged to Lake Druid.

It is recognized that some portion of the contaminated surficial aquifer beyond the point of stagnation of the circulation sphere would continue to migrate untreated to the lake for a short time. However, groundwater between the lake and the treatment sphere will be quickly replaced by treated groundwater exiting the circulation sphere.

The location of the recirculation and *in situ* stripping treatment system and its corresponding operational parameters will be evaluated during the design to ensure the RAO is met and to minimize the amount of contaminated groundwater that would migrate to the lake. Operational parameters, such as recirculation rates, will be evaluated by performing recirculation zone simulations.

In Situ (In-Well) Stripping. Groundwater would enter the system through a screen at the bottom of the recirculation well. While traveling though the specialized recirculation well, the groundwater is aerated, thereby volatilizing VOCs. These VOCs are subsequently transported out of the well by means of a vacuum blower.

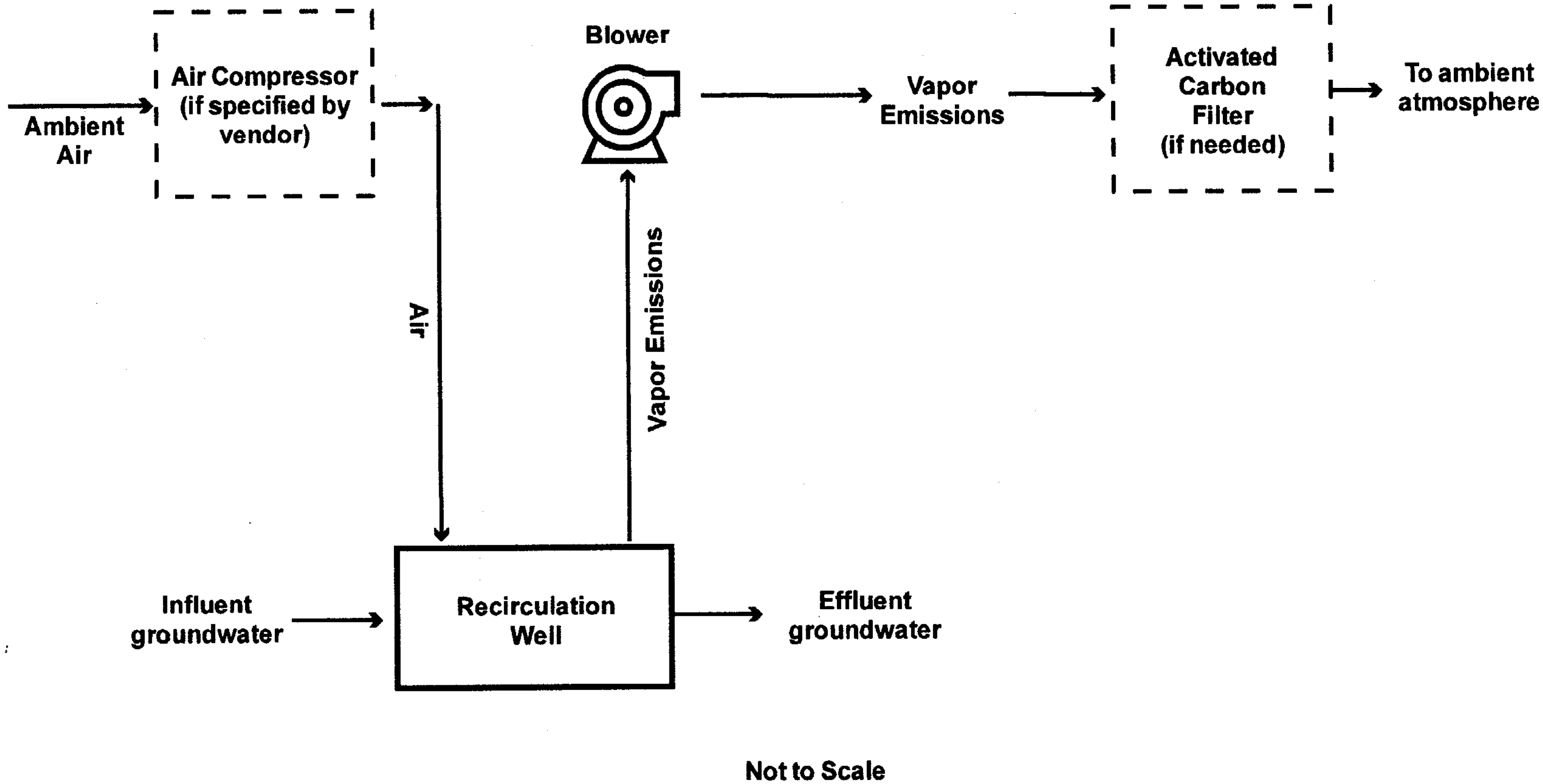

FIGURE 4-6
TREATMENT PROCESS TRAIN
FOR ALTERNATIVE 3:
RECIRCULATING/*IN SITU* WELL
STRIPPING

FOCUSED FEASIBILITY STUDY
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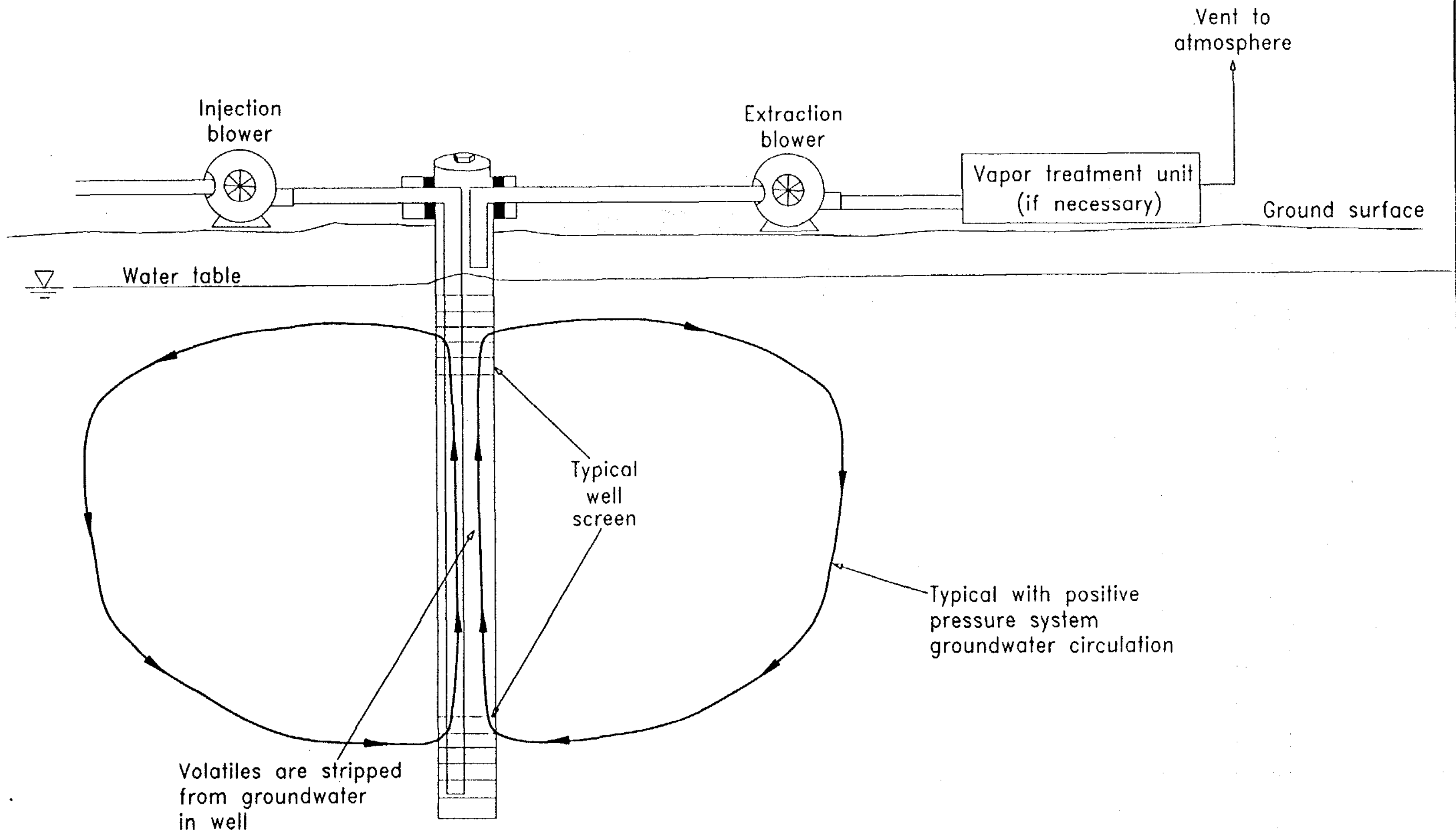

FIGURE 4-7
EXAMPLE SCHEMATIC FOR ALTERNATIVE 3: RECIRCULATION *IN SITU* WELL STRIPPING

FOCUSED FEASIBILITY STUDY
OPERABLE UNIT 4

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Treated groundwater reenters the aquifer from the top of the recirculation well, thus establishing a circular movement pattern (sphere) through the aquifer. Treatment levels for discharge to Lake Druid were identified in Chapter 2.0 (FSWQ standards for VOCs where applicable with a default of the Florida MCLs for other target VOCs).

Off-Gas. Based on preliminary calculations to estimate the concentration of VOCs in the off-gas from the recirculation and *in situ* stripping treatment system, it is not anticipated that off-gas treatment is necessary. However, samples of off-gas from the wells would be collected and analyzed for VOCs on a regular basis. In this manner, it is possible to identify whether or not off-gas treatment would become necessary. At this time, the only VOCs expected to be present in groundwater (based on the analytical data from groundwater samples during the pumping test), and therefore present in the off-gas, are PCE, TCE, and cis-DCE.

If treatment of the off-gas were to become necessary, vapor-phase GAC could be used to treat VOCs in accordance with action-specific ARARs for air treatment prior to discharge. At least two GAC canisters, connected in series, would be installed at the exhaust from the treatment systems. A stack would then be installed after the second GAC canister to adequately disperse the treated exhaust.

Groundwater, Surface Water, Sediment, and System Monitoring. Monitoring of groundwater, surface water, sediment, and off-gas of the recirculation and *in situ* stripping treatment system is proposed on a weekly basis for the first month, then monthly for the next 3 months, and then quarterly until the end of the anticipated operational period for the system (i.e., 1 year).

All samples collected during the monitoring program would be analyzed for TCL analytical parameters. Additional parameters may be added, as necessary, and would be based on data needs necessary for measuring specific performance parameters of the *in situ* system and for the overall RI/FS. Data would be used to evaluate the effectiveness of the recirculation and *in situ* stripping treatment system in decreasing VOC concentrations within the surficial aquifer and, subsequently, in surface water and sediment from Lake Druid. Data would be summarized and managed on a quarterly basis for use in the overall RI/FS.

Sampling locations, laboratory analyses, performance monitoring, protocol, etc. will be detailed in the design document and will be based on technology-specific requirements.

4.3.2 Technical Criteria Assessment

Overall Protection of Human Health and the Environment. An evaluation of how this alternative reduces human health and environmental risk over baseline conditions cannot be completed at this time (February 1997) because a baseline risk assessment has not yet been completed for OU 4. However, by implementing this alternative, hydraulic control over the portion of the aquifer with total VOCs greater than 100 $\mu g/\ell$ should be obtained. During implementation of this alternative, groundwater containing VOCs would be intercepted and treated *in situ* through the circulation sphere via in-well stripping, thus reducing the mass of VOCs discharging into Lake Druid.

By implementing this alternative, no adverse short-term or cross-media effects are anticipated.

Compliance with ARARs. This alternative's compliance with ARARs identified in Chapter 2.0 is presented in Table 4-5.

Long-Term Effectiveness and Permanence. Although this FFS was prepared for the OU 4 IRA, this alternative does offer a long-term and permanent remedy for aquifer remediation, without relying on natural transformation processes. Recirculation and *in situ* stripping treatment of groundwater removes VOCs *in situ* within the capture zone sphere, thus reducing the available mass of contaminants in groundwater that eventually discharge into Lake Druid.

Implementing this alternative does not directly address other contaminated media at the site. Groundwater, surface water, and sediment monitoring would provide a means of evaluating the concentrations of contaminants in these media over the IRA timeframe (i.e., 1 year), and would provide a means of evaluating the effectiveness of the alternative.

Reduction of Toxicity, Mobility, and Volume of Contaminants through Treatment. This alternative would permanently reduce the toxicity, mobility, and volume of VOCs in groundwater. VOCs would be treated *in situ* via in-well air stripping, and the off-gas from the air stripper would be monitored to determine whether or not collection and treatment via GAC is necessary. Predicted removal rates and treatment levels for this alternative were discussed in Chapter 2.0 and would be achieved under this alternative.

Short-Term Effectiveness. By implementing this alternative, the migration of groundwater contamination to Lake Druid would be affected immediately. Contaminated groundwater would be intercepted and treated *in situ*, thereby reducing the migration of VOCs into Lake Druid. No other additional short-term effects are anticipated. Installing a recirculation well and treating the groundwater should not pose a significant risk to workers or the community.

Implementability. Construction of the recirculation and *in situ* stripping treatment system is relatively easy to implement and would not pose a threat to workers or the community. Components of the proposed system are proprietary.

Cost. The present worth cost of this alternative is presented in Table 4-6. This estimate includes site preparation, installation of the recirculation and *in situ* stripping treatment system, system maintenance, and utilities for the duration of system operation (1 year).

Direct costs include site preparation, treatment system costs, and licensing. Direct costs for performance evaluation of the alternative include installation of monitoring wells for the proposed groundwater monitoring program. Total direct costs are estimated to be approximately $241,000.00, total O&M costs are estimated to be $25,200.00, total site monitoring costs are estimated to be $43,200.00, and total reporting costs are estimated to be $5,400.00. The total cost for this alternative is therefore estimated to be $314,800.00. Cost basis is included in Appendix F.

Table 4-5
Federal and State Regulatory Requirements *In Situ* Air Stripping Alternative

Focused Feasibility Study
Operable Unit 4
Naval Training Center
Orlando, Florida

Name and Regulatory Citation	Description	Consideration in the Corrective Action Process
Clean Air Act Regulations, National Emission Standards for Hazardous Air Pollutants [40 CFR Part 61]	Regulations contain emission standards and monitoring requirements for hazardous air pollutants that are likely to cause an increase in mortality or serious illnesses to humans.	TCE, PCE, DCE, cis-DCE, and VC are considered "hazardous air pollutants." Although NESHAP don't generally apply to remedial sites because these sites don't have the sources that are regulated, the emission standards for the Perchloroethylene Dry-Cleaning Industry could be used as "to be considered" guidance.
Clean Water Act Regulations, Water Quality Standards [40 CFR Part 131]	Establishes ambient water quality criteria (AWQC). AWQC are nonenforceable, ecological, and health-based criteria for carcinogenic and noncarcinogenic compounds and are used by states, in conjunction with a designated use for the surface water body, to establish water quality standards.	In the absence of Florida water quality standards that are specific to the pollutants of concern, these standards would apply.
Occupational Safety and Health Act (OSHA) Regulations, Occupational Safety and Health Standards [29 CFR Part 1910]	Provides fundamental requirements to ensure worker health and safety at hazardous waste sites.	Corrective action work must be conducted in accordance with these requirements.
OSHA Regulations, Toxic and Hazardous Substances Regulations [29 CFR Part 1910, Subpart Z]	Establishes permissible exposure limits for workplace exposure to a specific listing of chemicals.	Standards are applicable for worker exposure to OSHA hazardous chemicals during corrective action.
OSHA Regulations, Recording and Reporting Occupational Injuries and Illnesses [29 CFR Part 1904]	Provides recordkeeping and reporting requirements for enforcement of the Act and for developing information regarding the causes and prevention of occupational accidents and illnesses.	Requires the onsite maintenance of records of injuries and illnesses and requires reporting to OSHA of serious illnesses.
Florida Environmental Resource Permits [Chapter 62-341, FAC]	Section 341.475 provides criteria for obtaining a "general permit for minor activities" for dredging or filling of less than 100 square feet of wetlands or other surface waters.	This type of permit may be required for installing the air stripping equipment in the shoreline of the lake.
Florida Surface Water Quality Standards [Chapter 62-302, FAC]	The rule differentiates surface water into five classes based on designated uses and establishes ambient water quality standards (called, Florida Water Quality Standards) for listed pollutants. Because Florida criteria are specifically tailored to site circumstances, they should be used to establish cleanup levels rather than the Federal AWQC.	Lake Druid is classified as surface water III. The AWQS would be relevant in determining the levels of pretreatment necessary before the groundwater may be discharged to surface water. Florida has criteria for TCE, PCE and DCE but not VC or cis-DCE; therefore, Federal criteria would be used.
Florida Groundwater Classes, Standards and Exemptions [Chapter 62-520, FAC]	The rule classifies the groundwaters of the State into five classes and establishes minimum "free from" criteria. The rule also specifies that classes I and II must meet the primary and secondary drinking water standards listed in Chapter 62-550, FAC.	The groundwater at OU 4 is Class II. Therefore, the groundwater must be treated to meet the primary and secondary drinking water standards listed in 62-550, FAC.

See notes at end of table.

Table 4-5 (Continued)
Federal and State Regulatory Requirements *In Situ* Air Stripping Alternative

Focused Feasibility Study
Operable Unit 4
Naval Training Center
Orlando, Florida

Name and Regulatory Citation	Description	Consideration in the Corrective Action Process
Florida Drinking Water Standards [Chapter 62-550, FAC]	Rule adopts Federal primary and secondary drinking water standards.	Since groundwater is classified, G-II, these standards should be considered when establishing cleanup levels.
Florida Rules on Permits [Chapter 62-4, FAC]	Provides permitting requirements for water pollution sources and air emission units.	A permit for the air stripper off-gas would be required unless the project qualifies as an insignificant source under the exemptions in Chapter 62-4.040, FAC.
Groundwater Guidance Concentrations, Bureau of Groundwater Protection, June 1994.	Establishes maximum concentration levels for groundwater contaminants in the State of Florida. Groundwater with concentrations less than the listed values are considered "free from" contamination.	The values in this guidance should be considered when determining cleanup levels for groundwater.
Approach to the Assessment of Sediment Quality in Florida Coastal Waters, 1995.	The guidelines should be considered when evaluating potential biological harm posed by contaminated sediments in coastal waters.	These guidelines may be used for analyzing the sediment quality after air stripping has begun.
Soil Cleanup Goals for Florida, September 1995.	Provides guidance for soil cleanup levels, which can be developed on a site-by-site basis using the calculations in Appendix B of the document.	These guidelines aid in determining leachability-based cleanup goals for soil.

Notes: CFR = Code of Federal Regulations.
TCE = trichloroethene.
PCE = tetrachloroethene.
DCE = 1,1-dichloroethene.
cis-DCE = cis-1, 2-dichloroethene.
VC = vinyl chloride.
NESHAP = National Emission Standards for Hazardous Air Pollutants.
FAC = Florida Administrative Code.

Table 4-6
Estimated Cost for Recirculation/*In Situ* Stripping

Focused Feasibility Study
Operable Unit 4
Naval Training Center
Orlando, Florida

Item Description	Quantity	Total Cost ($)
CORRECTIVE ACTION IMPLEMENTATION		
Planning and Procurement[1]		14,500.00
Installation Services[2]		
• Recirculation Well/Development	2	26,800.00
• Monitoring Wells[3]	6	7,200.00
• Drilling IDW		8,000.00
• Trenching and Piping	600 ft	1,800.00
• *In Situ* Stripping System "Equipment"	2	127,500.00
• Misc. Piping and Valves		2,000.00
• Electrical Service Wiring		4,000.00
• System "Installation"	2	19,000.00
• Startup and Optimization		10,000.00
• Enclosures		4,000.00
Surveying		700.00
Permitting		
• Air Discharge		
Permit Preparation		1,500.00
Construction Management		
• Labor		14,000.00
Subtotal		241,000.00
See notes at end of table.		

Table 4-6 (Continued)
Estimated Cost for Recirculating/*In Situ* Stripping

Focused Feasibility Study, Operable Unit 4
Naval Training Center
Orlando, Florida

Item Description	Quantity	Total Cost ($)
OPERATION AND MAINTENANCE (per month)		
Professional Services		1,600.00
Utilities		400.00
Equipment and Supplies		100.00
Subtotal (per month)		2,100.00
Subtotal (project life)		**25,200.00**
SITE MONITORING[4] (per month)		
Professional Services		2,700.00
Analytical		900.00
Subtotal (per month)		3,600.00
Subtotal (project life)		43,200.00
REPORTING[5] (per month)		
Professional Services (Labor)		450.00
Subtotal (per month)		450.00
Subtotal (project life)		**5,400.00**
	TOTAL:	**314,800.00**

[1] Subcontractor coordination, equipment specification review and approval, project management, health and safety, scheduling, mobilization, and demobilization.
[2] Prices include equipment, material, and installation.
[3] Monitoring wells installed for site monitoring activities.
[4] Twelve times over the life of the project.
[5] Six reports over the life of the project.

Notes: Project life is assumed to be 1 year.
No travel costs associated with Operations and Maintenance or Site Monitoring activities.
No off-gas treatment estimated.
ft = feet.
IDW = investigation-derived wastes.

5.0 COMPARATIVE ANALYSIS OF REMEDIAL ALTERNATIVES

Remedial alternatives for OU 4 were developed in Chapter 3.0 and were individually evaluated in Chapter 4.0 using seven technical criteria. For comparative purposes, these criteria are grouped into the following categories:

- threshold criteria,
- primary balancing criteria, and
- modifying criteria.

The remainder of this chapter presents a comparison of remedial alternatives with respect to these criteria. This comparison is intended to provide technical information required to support the selection of a preferred alternative for the OU 4 IRA.

5.1 OVERALL APPROACH TO COMPARATIVE ANALYSIS. As presented in Chapter 4.0, remedial alternatives were developed to accomplish the RAO identified for the OU 4 IRA. The RAO was based on gaining control over the groundwater contaminant migration pathways of VOCs that contribute to surface water exceedances in Lake Druid. The three sets of criteria identified above are used to streamline the comparison between alternatives, while ensuring compliance with the RAO. Components of these criteria are described below.

5.1.1 Threshold Criteria Because the selected remedy must be protective of human health and the environment, as well as comply with ARARs, the following two threshold criteria are essential:

- overall protection of human health and the environment and
- compliance with ARARs.

An individual assessment of each alternative with respect to these criteria was presented in Chapter 4.0. An overall comparative analysis of alternatives using threshold criteria is presented in Section 5.2.

5.1.2 Primary Balancing Criteria Primary balancing criteria consist of the following five components:

- long-term effectiveness and permanence;
- reduction of toxicity, mobility, and volume;
- short-term effectiveness;
- implementability; and
- cost.

These criteria are used to provide an assessment of the permanence of each remedial alternative, while ensuring their implementability and cost effectiveness. These criteria ensure the use of treatment technologies that reduce the toxicity, mobility, or volume of contaminants rather than technologies that solely prevent exposure. An individual assessment of each alternative with respect to these criteria is presented in Chapter 4.0. An overall comparative analysis of alternatives using primary balancing criteria is presented in Subsection 5.2.2.

5.1.3 Modifying Criteria The final two criteria are listed below:

- State acceptance and
- community acceptance.

The FDEP and USEPA have reviewed and participated in selection of the preferred remedy for the OU 4 IRA. Additionally, a Restoration Advisory Board meeting was held in January 1997 to discuss the preferred remedy with the community. These criteria were considered in selecting the preferred alternative for the OU 4 IRA.

5.2 COMPARATIVE ANALYSIS. The following sections present a comparison between each alternative.

Overall Protection of Human Health and the Environment. An evaluation of how any alternative reduces human health and environmental risk over baseline conditions cannot be completed at this time (February 1997) because a baseline risk assessment has not yet been completed for OU 4. However, by implementing any of the alternatives, the reduction of concentrations of VOCs in groundwater should be achieved, thus limiting one migration pathway for VOCs entering Lake Druid.

Alternative 1 would provide an aggressive groundwater extraction and treatment system (i.e., pump-and-treat) to directly remove VOCs from groundwater and establish hydraulic control. These alternatives are proven techniques for removing the bulk of contamination, but experience has shown that attainment of treatment levels within the surficial aquifer may be technically impractical.

Alternatives 2 and 3 are not as well demonstrated as Alternative 1. Although mechanical intervention is included in Alternatives 2 and 3, their effectiveness is less predictable as they are either strongly dependent on site lithology (Alternative 2) or require complex modeling of a proprietary technology (Alternative 3).

However, by implementing Alternative 3, hydraulic control over the portion of the aquifer with total VOCs greater than 100 $\mu g/\ell$ should be obtained. If this alternative were implemented, groundwater containing VOCs would be intercepted and treated *in situ* through the circulation sphere via in-well stripping, thus reducing VOC contaminant mass discharging into Lake Druid.

Compliance with ARARs. All alternatives are anticipated to eventually achieve ARARs.

5.2.1 Comparison of Primary Balancing Criteria

Long-Term Effectiveness and Permanence. It is anticipated that all three alternatives would be effective at achieving action levels and after a sufficient period of time would comply with ARARs. Alternatives 2 and 3 are independent systems, while Alternative 1 is dependent upon the facility's STP. If the STP were to close in the future before action levels are met in the aquifer, additional treatment would be required for discharge directly to surface water.

Alternatives 2 and 3 would remove VOCs *in situ*, thus reducing the available mass of contaminants in groundwater that eventually discharge into Lake Druid.

Reduction of Toxicity, Mobility, and Volume. Alternative 1 provides mechanical treatment processes to extract and treat contaminated groundwater. By extracting groundwater, the portion of the plume with the highest concentrations of VOCs would be controlled, preventing contaminant migration to Lake Druid. The selected technologies for treatment would provide reduction in toxicity, mobility, and volume of both organic and inorganic contaminants.

Conversely, Alternatives 2 and 3 would not include groundwater extraction. Alternative 2 uses air injection into the subsurface to strip VOCs from the groundwater. Alternative 3 relies on establishing a spherical recirculation zone in the aquifer, and stripping and removal of VOCs within the recirculation well. Both alternatives reduce contaminant toxicity, mobility, and volume by reducing the mass of VOCs in the aquifer and migrating into the lake.

However, Alternative 3 provides for greater reduction of the mass of VOCs in the aquifer due to the imposed vertical gradient, and the formation of the recirculation zone should provide more reliable contaminant reduction than Alternative 2.

Short-Term Effectiveness. Upon implementation, each alternative would immediately begin reduction of the mass of contaminants entering Lake Druid. All three alternatives include a mechanical treatment process for contaminant removal.

One possible short-term effect of implementing Alternative 2 versus Alternative 3 is that implementation of Alternative 2 may create groundwater upwelling near the air sparging locations. At OU 4, the groundwater table is only approximately 1.5 feet bls (in places), and it is possible that the upwelling effect may present itself as a pool of water on the ground surface. If this occurs, the potential exists for human and ecological receptors to be in direct contact with the contaminated groundwater and the contamination of soil in that area.

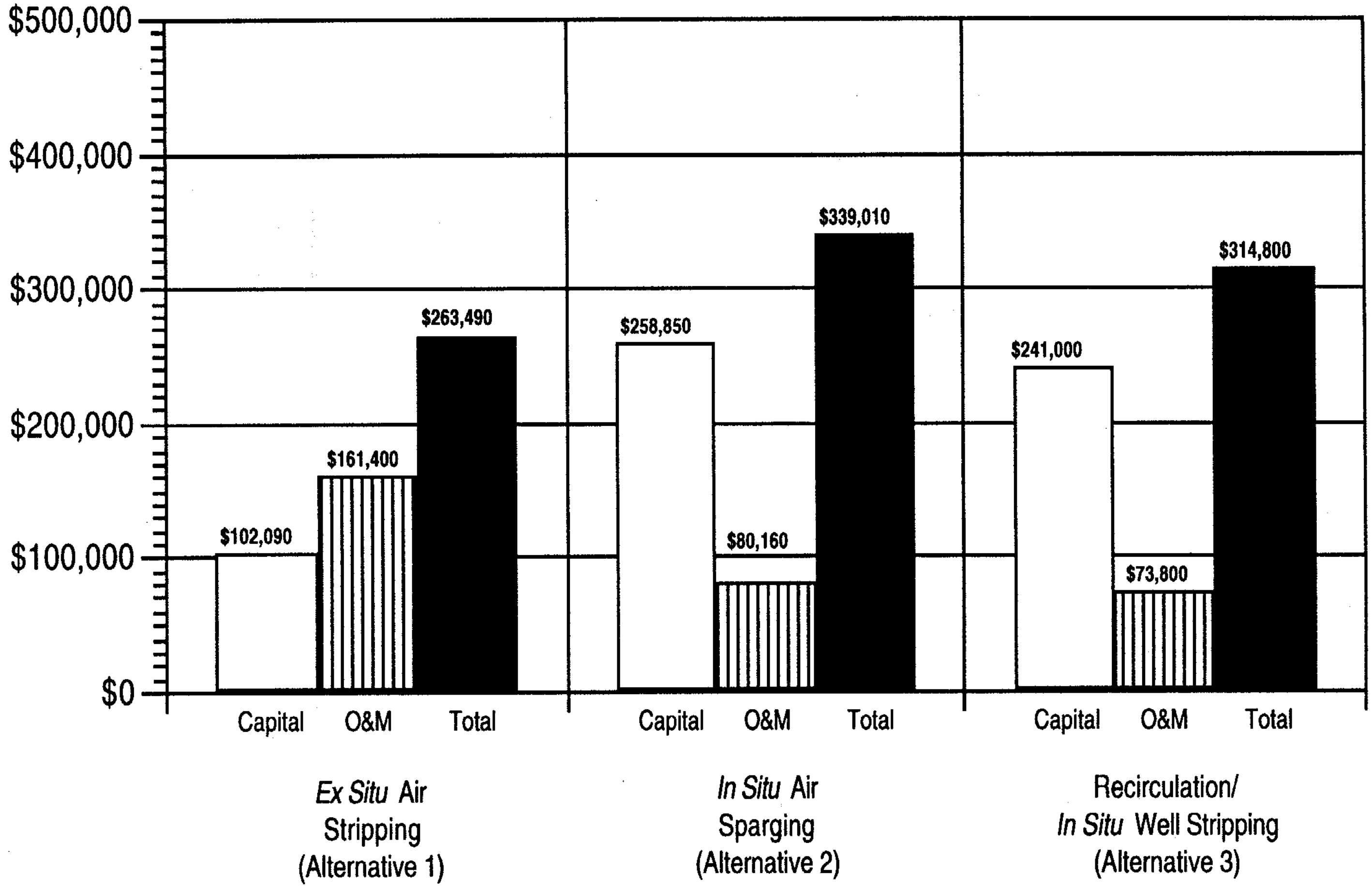
Implementability. Alternative 1 would be relatively easy to construct because it only includes minimal pretreatment of extracted groundwater (i.e., construction of an air stripper) for acceptance at the Orlando STP.

Alternative 2 includes the installation of air sparging and vapor extraction wells; it is relatively easy to implement.

Construction of the recirculation and *in situ* stripping treatment system for Alternative 3 is relatively easy to implement and would not pose a threat to workers or the community. Components of the proposed system for this alternative are proprietary.

Cost. The relative present-worth cost estimate for each alternative, based on a 30-year (in accordance with USEPA guidance) operating time, is presented on Figure 5-1.

5.2.2 Summary Figure 5-2 presents a summary of the comparative analysis for the OU 4 IRA remedial alternatives.



NOTE:
O & M = Operations and maintenance

FIGURE 5-1
COST COMPARISON BETWEEN ALTERNATIVES

FOCUSED FEASIBILITY STUDY
OPERABLE UNIT 4

NAVAL TRAINING CENTER
ORLANDO, FLORIDA

8545-73 FIG 5-1 050897MAW

	Overall protection of human health and the environment	Compliance with ARARs	Long-term effectiveness and permanence	Short-term effectiveness	Reduction of toxicity, mobility, and volume of contaminants through treatment	Overall cost for one year of operation	O&M, site monitoring, and reporting cost for one year of operaton	Consistent with final remedy	Regulatory/State acceptance	Implementability	Status - (F)ull or (P)ilot scale	Community acceptability	Time to implement (months)
GROUNDWATER													
Ex Situ Air Stripping	○	○	○	○	★	$264,000	$160,000	○	★	★	F	○	2-5
In Situ Air Sparging	○	○	○	●	○	$339,000	$80,000	○	●	○	P	○	4-6
Recirculation/In Situ Well Stripping	★	○	★	○	★	$313,000	$74,000	★	○	○	P-F	○	4-5

★ = Good

○ = Average

● = Below average

NOTE:
O & M = Operations and maintenance

FIGURE 5-2
COMPARATIVE ANALYSIS OF ALTERNATIVES

FOCUSED FEASIBILITY STUDY
OPERABLE UNIT 4

NAVAL TRAINING CENTER
ORLANDO, FLORIDA

SOUTHERN DIVISION NAVAL FACILITIES ENGINEERING COMMAND

8545-73 FIG 5-2 201397MAW

5.3 PREFERRED ALTERNATIVE FOR OU 4 IRA. The primary goal of alternative development for the OU 4 IRA was to gain control over the groundwater contaminant migration pathways of VOC concentrations that contribute to exceedances of FDEP surface water standards in Lake Druid. This goal was established in Chapter 2.0, and was based on the FFI results, which indicate that the source of the lake's contamination is most likely recharge of the contaminated groundwater to Lake Druid.

Because site characterization has not been fully completed at OU 4 (i.e., the overall RI/FS is yet to be completed), treatment alternatives were developed using a streamlined process that considers achievement of the RAO, effectiveness, implementability, and cost for this IRA. Evaluation of complex or innovative technologies (e.g., *in situ* treatment technologies such as permeable reactive walls) generally requires a more complete site characterization than is available at this stage. Therefore, evaluation of these complex or innovative technologies is deferred to the overall RI/FS.

Remedial alternatives were developed for the OU 4 IRA in Chapter 3.0 and were described and evaluated in Chapter 4.0. A comparative analysis of the alternatives has been presented in this chapter.

Based on this analysis, the *in situ* in-well air stripping alternative is the preferred alternative for the OU 4 IRA. This alternative would gain control over the groundwater migration pathways of VOC concentrations that contribute to exceedances of FDEP surface water standards in Lake Druid. This alternative would be effective in treating VOCs in groundwater to treatment levels and is relatively easy to implement.

The applicability of this alternative as the long-term solution for OU 4 will be reevaluated in the overall RI/FS for the OU. It is possible that the ultimate remedy for OU 4 may be different from this selected alternative, or the recommended alternative may become a part of the final solution for the OU.

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APPENDIX A

CALCULATIONS FOR GROUNDWATER EXTRACTION SYSTEM

PROJECT Capture Zone Analysis	COMP. BY H.F.	JOB NO. 8519.59
	CHK. BY SBL	DATE 9-24-96

Capture Zone Width (CZW) = $\frac{Qw}{2Ti}$ @ recovery well

Qw = Flow rate in gpd
T = Transmissivity - derived from distance drawdown curve plotted following pumping test gpd/ft (14,700 gpd/ft)

i = Hydraulic Gradient

CZW @ 30gpm = $\frac{30(1440)}{2(14,700)(0.017)}$ = 86.43 ft ✓

CZW @ 40gpm = $\frac{40(1440)}{2(14,700)(0.017)}$ = 115.25 ft ✓

CZW @ 50gpm = $\frac{50(1440)}{2(14,700)(.017)}$ = 144.06 ft ✓

Distance of stagnation Point from recovery well (DSP)

DSP = $\frac{Qw}{2\pi Ti}$

DSP @ 30gpm = 27.5 ft ✓ Dsp @ 80gpm = 73.4

DSP @ 40gpm = 36.7 ft ✓ Dsp @ 70gpm = 64

DSP @ 50gpm = 45.88 ft ✓

Extraction Well Spacing

2 wells ⇒ 0.32 $\frac{Q}{2Ti}$

@ 40gpm = 0.32 $\frac{40(1440)}{2(14,700)(.017)}$ = 36.8 f

@ 50gpm = 46.1 ft

APPENDIX B

CONCENTRATIONS OF CHEMICALS IN EXTRACTED GROUNDWATER, OU 4 PUMPING TEST

Summary of Groundwater Analytical Results and Florida Surface Water Standards
Operable Unit 4

Naval Training Center, Orlando
Orlando, FL

Identifier	ETP-1		ETP-2		ETP-3		
SampleID	96080206-1		96080206-2		96080206-3		
Sampling Date	8/29/96		8/29/96		8/30/96		Florida Surface Water Discharge Criteria
Organics, ug/L							
1,1,1,2-Tetrachloroethane	20	U	20	U	20	U	
1,1,1-Trichloroethane	20	U	20	U	20	U	
1,1,2,2-Tetrachloroethane	20	U	20	U	20	U	<=10.8 ug/L annual average
1,1,2-Trichloroethane	20	U	20	U	20	U	
1,1-Dichloroethane	20	U	20	U	20	U	
1,1-Dichloroethene	20	U	20	U	20	U	<= 3.2 ug/L annual average
1,2,3-Trichloropropane	20	U	20	U	20	U	
1,2-Dibromomethane	20	U	20	U	20	U	
1,2-Dichlorobenzene	20	U	20	U	20	U	
1,2-Dichloroethane	20	U	20	U	20	U	
1,2-Dichloropropane	20	U	20	U	20	U	
1,3-Dichlorobenzene	20	U	20	U	20	U	
1,4-Dichlorobenzene	20	U	20	U	20	U	
2-Butanone	500	U	500	U	500	U	
2-Chloroethyl vinyl ether	20	U	20	U	20	U	
2-Hexanone	500	U	500	U	500	U	
4-Methyl-2-pentanone	500	U	500	U	500	U	
Acetone	500	U	500	U	500	U	
Acetonitrile	500	U	500	U	500	U	
Acrolein	500	U	500	U	500	U	
Acrylonitrile	500	U	500	U	500	U	
Benzene	20	U	20	U	20	U	<=71.28 ug\L annual average
Bromodichloromethane	20	U	20	U	20	U	
Bromoform	20	U	20	U	20	U	<= 360 ug/L annual average
Bromomethane	20	U	20	U	20	U	
Carbon disulfide	500	U	500	U	500	U	
Carbon tetrachloride	20	U	20	U	20	U	<=4.42 ug/L annual average
Chlorobenzene	20	U	20	U	20	U	
Chlorodibromomethane	20	U	20	U	20	U	<= 34 ug/L annual average
Chloroethane	20	U	20	U	20	U	
Chloroform	20	U	20	U	20	U	<= 470.8 ug/L annual average
Chloromethane	20	U	20	U	20	U	<=470.8 ug/L annual average
cis-1,2-Dichloroethene	570		572		606		
cis-1,3-Dichloropropene	20	U	20	U	20	U	
Dibromomethane	20	U	20	U	20	U	
Dichlorodifluoromethane	20	U	20	U	20	U	
Ethylbenzene	20	U	20	U	20	U	
Methylene chloride	20	U	20	U	20	U	<= 1,580 ug/L annual average
MTBE	100	U	100	U	100	U	
Styrene	20	U	20	U	20	U	
Tetrachloroethene	172		124		90		<=8.85 ug/L annual average
Toluene	20	U	20	U	20	U	
trans-1,2-Dichloroethene	20	U	20	U	20	U	
trans-1,3-Dichloropropene	20	U	20	U	20	U	
Trichloroethene	2660		2380		2220		<=80.7 ug/L
Trichlorofluoromethane	20	U	20	U	20	U	
Vinyl acetate	500	U	500	U	500	U	
Vinyl chloride	20	U	20	U	20	U	
Xylenes (total)	20	U	20	U	20	U	
Inorganics, ug/L							
Aluminum, Filtered	160		100		110		
Aluminum, Total	220		200		190		
Antimony, Filtered	5	U	5	U	5	U	
Antimony, Total	5	U	5	U	5	U	<=4,300 ug/L
Arsenic, Filtered	5	U	5	U	5	U	

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Summary of Groundwater Analytical Results and Florida Surface Water Standards
Operable Unit 4

Naval Training Center, Orlando
Orlando, FL

Identifier	ETP-1	ETP-2	ETP-3	
SampleID	96080206-1	96080206-2	96080206-3	
Sampling Date	8/29/96	8/29/96	8/30/96	Florida Surface Water Discharge Criteria
Bacteriological Quality (total coliform bacteria)				<=1,000 as a monthly average; nor exceed 1,000 in more than 20% of the samples examined during any month; <=2,400 at any time. Monthly averages shall be expressed as geometric means based on a minimum of 10 samples taken over a 30 day period using either the MPN or MF counts
Bacteriological Quality (fecal coliform bacteria)				MPN or MF counts shall not exceed a monthly average of 200 nor exceed 400 in 100% of the samples, nor exceed 800 on any one day. Monthly averages shall be expressed as geometric means based on a minimum of 10 samples taken over a 30 day period.
Biological Integrity				The index for benthic macroinvertebrates shall not be reduced to less than 75% of established background levels as measured using organisms retained by a U.S. Standard No. 30 sieve and collected and composited from a minimum of three Hester-Dendy type artificial substrate samplers of 0.10 to 0.15 m^2 area each, incubated for a period of four weeks.
BOD				Shall not be increased to exceed values which would cause dissolved oxygen to be depressed below the limit established for each class and, in no case, shall it be great enough to produce nuisance conditions.
Chromium (trivalent)				<=$e^{[0.819(\ln H)+1.561]}$ ug/L
Chromium (hexavalent)				<=11 ug/L
Chronic Toxicity				see Section 62-302.200(3), F.A.C.
Chlorine (total residual)				<=0.01 mg/L
Conductance, specific				Shall not be increased more than 50% above background or to 1275 micromhos/cm, whichever is greater
Cyanide				<=5.2 ug/L
Detergents				<=0.5 mg/L
2,4-Dinitrotoluene				<= 9.1 ug/L annual average
Dissolved Oxygen				Shall not be less than 5.0 mg/L. Normal Daily and seasonal fluctuations above these levels shall be maintained
Fluorides				<= 10.0 mg/L
Dichlorobromomethane				<= 22 ug/L annual average
Hexachlorobutadiene				<= 49.7 ug/L annual average
Nuisance Species				substances which result in the dominance of nuisance species: none shall be present.
Nutrients (a)				The discharge of nutrients shall continue to be limited as needed to prevent violations of other standards contained in this chapter. Man-induced nutrient enrichment (total nitrogen or total phosphorus) shall be considered degredation in relation to the provisions of Sections 62-302.300, 62-302.700, and 62-4.242, F.A.C.
Nutrients (b)				In no case shall nutrient concentrations of a body of water be altered so as to cause an imbalance in natural populations of aquatic flora and fauna.
Oils and greases (a)				Dissolved or emulsified oils and greases shall not exceed 5.0 mg/L
Oils and greases (b)				No undissolved oil, or visible oil defined as iridescence, shall be present so as to cause taste or odor, or otherwise interfere with the beneficial use of waters.

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APPENDIX C

EVALUATION PACKET FOR OU 4 IRA

PROJECT	COMP. BY	JOB NO.
Groundwater NTC ORLANDO FFIR OU4 MASS FLUX TO LAKE DRUID	HKW	C8519.93
	CHK. BY	DATE
	[illegible]	12/3/96

$Q = KiA$

DETERMINE GROUNDWATER VOC MASS FLUX RATES IN DIRECTION OF LAKE DRUID

ASSUMPTIONS: (1) $K = 32.7$ ft/d - based on pumping test

(2) $i = 0.012$ - also from pumping test

(3) AREAS (A) WILL BE BASED ON CONCENTRATIONS DETECTED ALONG A-A' CROSS-SECTION (FIGURE 4.4 IRA - FFIR FOR OU4)

$\frac{mass}{YR} = Q\left(\text{CONCENTRATION}, \frac{mass}{volume}\right)$

A. DETERMINE MASS LOADING THROUGH A-A' WINDOW FOR TOTAL VOCs > 1000 ppb

ASSUME NO DISPERSION, SORPTION, OR DEGRADATION
CALCULATE FOR ADVECTION ONLY

$A = 840$ ft^2 (SEE AREA CALCS.)

A.1. $\frac{\text{pounds TCE}}{YR} = \left(\frac{590\,\mu g}{L}\right)\left(\frac{3.785\,L}{gal}\right)\left(\frac{7.48\,gal}{ft^3}\right)\left(\frac{32.7\,ft}{day}\right)(0.012)(840\,ft^2)$

$= 5{,}505{,}893.1\,\mu g/day = 5.5\,\frac{g}{day}\left(\frac{365\,day}{yr}\right)\left(\frac{lb}{453.597\,g}\right) = \underline{4.4\,lb/yr}$ TCE

A.2 $\frac{\text{pounds PCE}}{yr} = \left(21.6\,\frac{\mu g}{L}\right)\left(9{,}332.0\,\frac{L}{day}\right) = 201{,}571.2\,\mu g/day = \underline{0.2\,lb/yr}$ PCE

← weighted average (SEE CALC. PAGE)

A.3 $\frac{\text{pound DCE}}{yr} = \left(635\,\frac{\mu g}{L}\right)\left(9{,}332.0\,\frac{L}{day}\right) = 5{,}925{,}820.0\,\mu g/day = \underline{4.8\,lb/yr}$ DCE

A.4 $\frac{\text{pounds VC}}{yr} = \left(0.8\,\frac{\mu g}{L}\right)\left(9{,}332.0\,\frac{L}{day}\right) = 7{,}465.6\,\mu g/day = \underline{0.006\,lb/yr}$ VC

PROJECT	COMP. BY	JOB NO.
NTC ORLANDO - LAKE DRUID MASS FLUX	HR	08579.93
	CHK. BY	DATE
	MJB	12/3/96

2/4

A. (CONTINUED)

IN REGION (WINDOW) OF TVOCs > 1000 ppb

$$\frac{VOCs}{YR} = 4.4 + 0.2 + 4.8 + 0.006 = \underline{\underline{9.4\ \frac{lb}{yr}}}$$

B. DETERMINE LOADING THROUGH A-A' WINDOW FOR 100 ppb < TOTAL VOCs > 1000 ppb   ADVECTION ONLY

A = 4,514 ft²

ALL CONCENTRATIONS ARE APPROXIMATE WEIGHTED AVERAGES (SEE CALC. PAGE)

B.1 $\frac{\text{pounds TCE}}{\text{yr}} = \left(\frac{1021\ \mu g}{L}\right)\left(\frac{3.785\ L}{gal}\right)\left(\frac{7.48\ gal}{ft^3}\right)\left(\frac{32.7\ ft}{day}\right)(0.012)(4,514\ ft^2)$

$= 5,120,163\ \mu g/day = 5.1\ \frac{g}{day}\left(\frac{365\ day}{yr}\right)\left(\frac{lb}{453.597\ g}\right) = \underline{4.1\ \frac{lb}{yr}}$ TCE

B.2 $\frac{\text{pounds PCE}}{\text{yr}} = \left(\frac{153\ \mu g}{L}\right)\left(50,148.5\ \frac{L}{day}\right) = 7,672,720\ \frac{\mu g}{day} = \underline{6.2\ \frac{lb}{yr}}$ PCE

B.3 $\frac{\text{pound DCE}}{\text{yr}} = \left(\frac{100\ \mu g}{L}\right)\left(50,148.5\ \frac{L}{day}\right) = 5,014,850\ \frac{\mu g}{day} = \underline{4.0\ \frac{lb}{yr}}$ DCE

B.4 $\frac{\text{pound VC}}{\text{yr}} \approx \underline{0\ \frac{lb}{yr}}$ VC

IN REGION OF 100 ppb < TOTAL VOCs > 1000 ppb

$$\frac{VOCs}{YR} = 4.1 + 6.2 + 4.0 = \underline{\underline{14.3\ lb/yr}}$$

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ABB Environmental Services, Inc.

PROJECT	COMP. BY	JOB NO.
NTC ORLANDO - LAKE ORLANDO MASS FLUX	HKW	08519.93
	CHK. BY	DATE
	MJ	12/3/96

AREA + AVERAGE CONCENTRATION CALCULATIONS

AREA A

A1 → 45' × 2.64 = 118.80

A2 → (45' × 3.0)/2 = 67.5

A3 → 43.6 × 3.6 = 157.0

A4 → 43.6 × 1.8 = 78.5

A5 → 43.6 × 3.72 = 162.19

A6 → 42.7 × 1.8 = 76.9

A7 → 49.5 × 3.6 = 178.2

A_{TOTAL} = 840 ft^2

AVG. CONC. FOR AREA A BY CHEMICAL

TCE $\frac{420 + 990 + 270 + 680}{4}$ = 590 mg/L

PCE = $\frac{1.6 + 75 + 1.7 + 8.1}{4}$ = 21.6 mg/L

DCE = $\frac{230 + 520 + 1100 + 690}{4}$ = 635 mg/L

VC = $\frac{0 + 0 + 3 + 0}{4}$ = .75 mg/L

AREA B

B1 → (33.75 × 12)/2 = 202.50

B2 → (33.75 × 10.2)/2 = 172.12

B3 → (40.5 × 2.4)/2 = 48.60

B4 → (40.5 × 15) = 607.5

B5 → (40.5 × 3.6)/2 = 72.9

B6 → (42.75 × 3.6)/2 = 76.95

B7 → (42.75 × 15) = 641.25

B8 → (42.75 × 8.4)/2 = 179.55

B9 → (20.25 × 6) = 121.5

B10 → (63 × 9.6) = 604.8

B11 → (63 × 10.2) = 642.6

B12 → (63 × 3.6)/2 = 113.4

B13 → (47.25 × 4.2)/2 = 99.22

B14 → (47.25 × 10.8) = 510.3

B15 → (47.25 × 12)/2 = 283.5

B16 → (27 × 5.4)/2 = 72.9

B17 → (27 × 4.8)/2 = 64.8

B_{TOTAL} = 4,514 ft^2

AVG. CONC. FOR AREA B BY CHEMICAL

TCE = $\frac{110 + 93 + 110 + 190 + 270 + 160 + 310 + 130 + 180 + 56 + 11 + 12 + 1.7 + 23 + 5 + 3 + 71}{17}$ = 102.1 mg/L

PCE = $\frac{0 + 0 + 0 + 64 + 97 + 19 + 44 + 170 + 180 + 130 + 120 + 120 + 99 + 950 + 300 + 300 + 2.4}{17}$ = 153 mg/L

DCE = $\frac{410 + 370 + 830 + 4.4 + 4.8 + 2.2 + 5.0 + 3.0 + 4.7 + 4.2 + 0 + 0 + 0 + 6.7 + 1.6 + 1.2 + 54}{17}$ = 100 mg/L

VC ≅ 0

PROJECT	COMP. BY	JOB NO.
NTC ORLANDO - LAKE DRAIN MASS FLUX	HKW	08519.93
	CHK. BY: MJL	DATE: 12/3/96

AREA & AVG. CONCENTRATION CALCULATIONS (CONTINUED)

AREA C_i

$C1 \rightarrow (40 \times 10.65)\frac{1}{2} = 213$

$C2 \rightarrow (44 \times 8.52) = 374.88$

$C3 \rightarrow (80 \times 6.39) = 511.20$

$C4 \rightarrow (56 \times 5.32) = 297.92$

$C5 \rightarrow (44 \times 5.32)\frac{1}{2} = 117.04$

$C6 \rightarrow (44 \times 9.58)\frac{1}{2} = 210.76$

1724.8

$C7 \rightarrow (56 \times 4.26)\frac{1}{2} = 119.28$

$C8 \rightarrow (56 \times 2.13) = 119.28$

$C9 \rightarrow (36.8 \times 9.58)\frac{1}{2} = 176.27$

$C10 \rightarrow (36.8 \times 4.26) = 156.77$

$C11 \rightarrow (38.4 \times 4.26)\frac{1}{2} = 81.79$

$C12 \rightarrow (16.8 \times 14.91) = 250.32$

2628.5

$C13 \rightarrow (68 \times 7.45)\frac{1}{2} = 253.3$

$C14 \rightarrow (68 \times 13.84) = 941.12$

$C15 \rightarrow (68 \times 27.69)\frac{1}{2} = 941.46$

$C16 \rightarrow (64 \times 7.45) = 476.80$

$C17 \rightarrow (104 \times 34.08)\frac{1}{2} = 1{,}772.16$

$C18 \rightarrow (36 \times 7.45)\frac{1}{2} = 134.1$

$C19 \rightarrow (272 \times 1.06) = 288.32$

$C_{TOTAL} = \underline{7{,}436 \text{ ft}^2}$

AVG. CONC. FOR AREA C BY TVOC

30
19.8
12.5
4.7
5.8
13.4
0
10.6
51.1
15.9
13.9
19.7
2.2
33
28
66
25.2
22.7
16
26
0.6
23.2
21.6
124
6.5
17.8
497.6

$497.6 \div 26 = \underline{19.1 \text{ mg/L}}$

C. DETERMINE MASS FLUX THROUGH A-A' WINDOW FOR TOTAL VOCs <100 ppb - ADVECTION ONLY

$\frac{\text{POUNDS TVOC}}{\text{YR}} = (19.1 \text{ mg/L})\left(\frac{3.785 \text{ L}}{\text{gal}}\right)\left(\frac{7.48 \text{ gal}}{\text{ft}^3}\right)\left(\frac{32.7 \text{ ft}}{\text{day}}\right)(0.012)(7{,}436 \text{ ft}^2)$

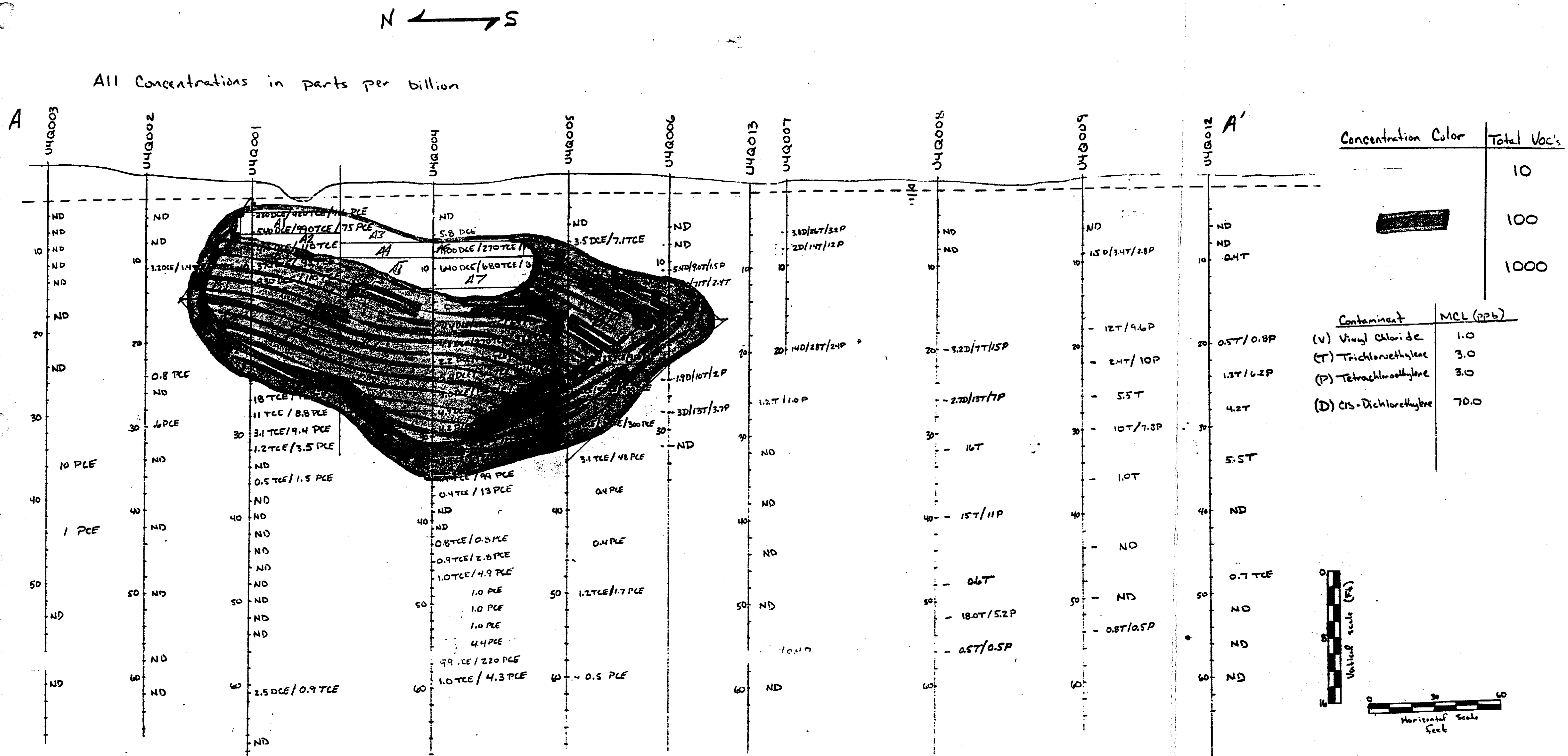
$= 1{,}577{,}863 \frac{\text{mg}}{\text{day}}\left(\frac{\text{g}}{10^3 \text{ mg}}\right)\left(\frac{365 \text{ day}}{\text{yr}}\right)\left(\frac{\text{lb}}{453.597 \text{ g}}\right) = \underline{\underline{1.3 \frac{\text{lb}}{\text{yr}}}} \text{ TVOC}$

IN REGION OF TVOC <100 ppb

$\text{FLUX} = 1.3 \frac{\text{lb}}{\text{yr}}$

FORM 00.01 REV. 4/81

ABB Environmental Services, Inc.



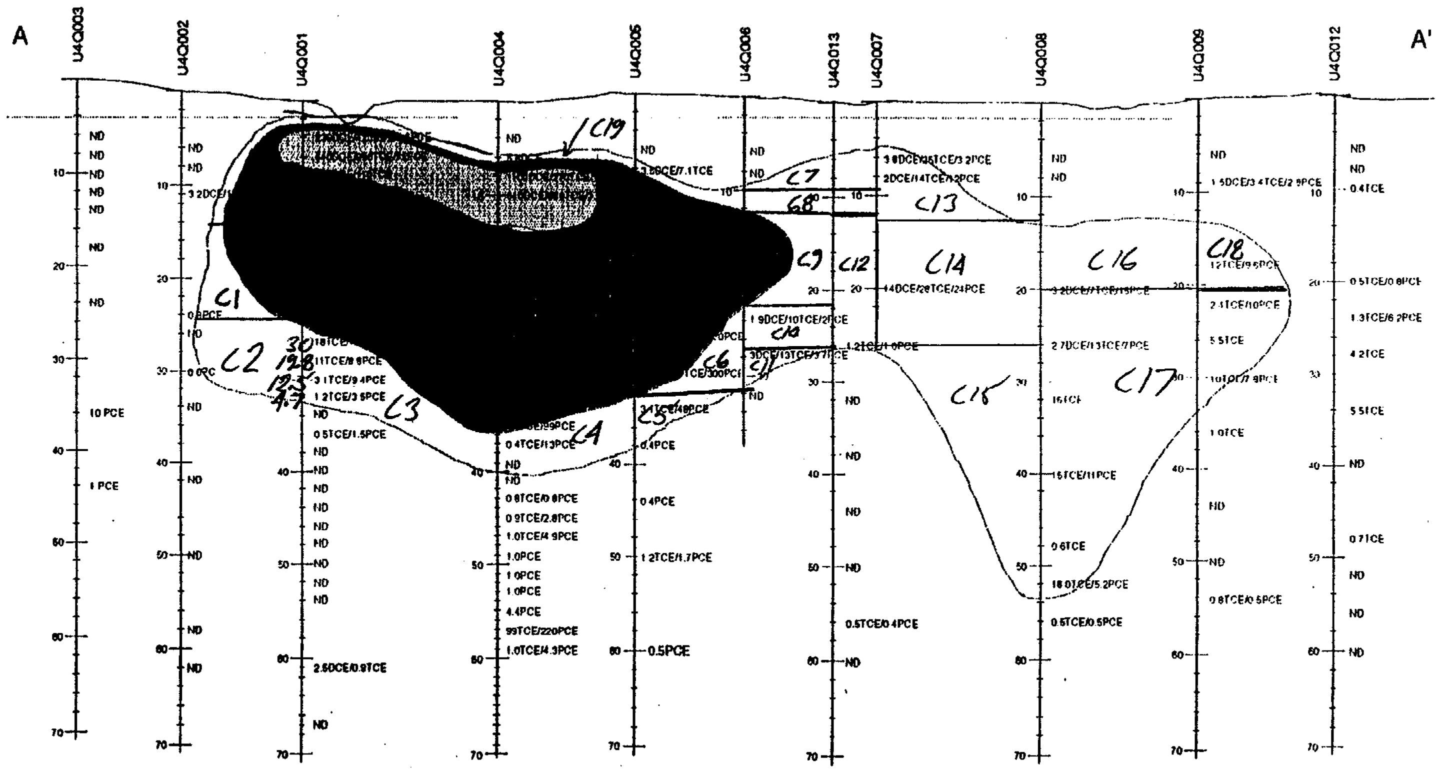
North-South Groundwater VOC Concentration Cross Section A-A'

Interim Remedial Action Focused Field Investigation Report, Operable Unit 4

Naval Training Center Orlando, Florida

00209A02Z

All concentrations in parts per billion



Contaminant	MCL (ppb)
(VC) Vinyl Chloride	1.0
(TCE) Trichloroethylene	3.0
(PCE) Tetrachloroethylene	3.0
(DCE) cis-Dichloroethylene	70.0

Concentration Color	Total VOC's
(white)	10
(black)	100
(stippled)	1000

Vertical Scale (ft) 0 8 16

Horizontal Scale (ft) 0 30 60

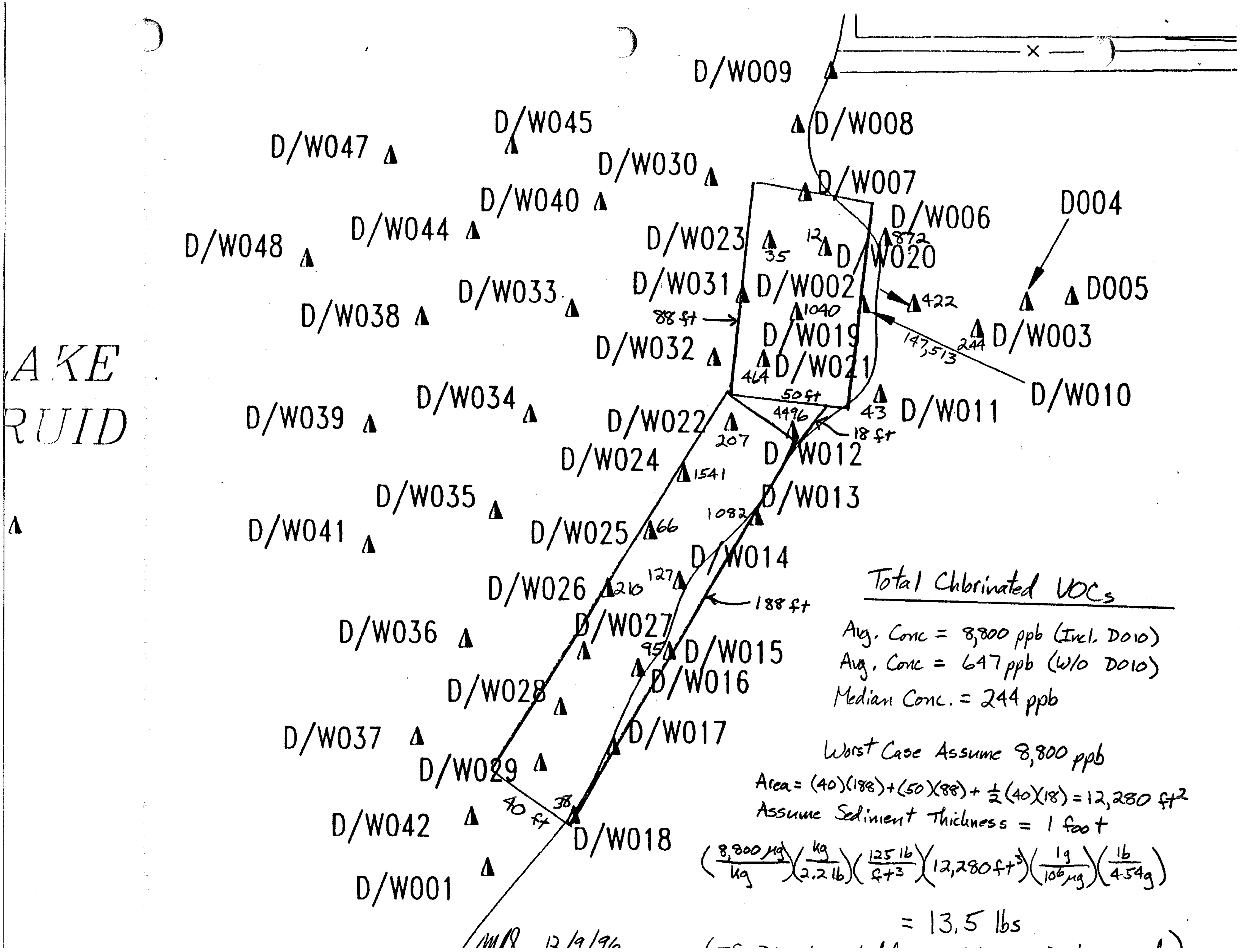
NOTE:
VOC = volatile organic compound

FIGURE 4-4
NORTH-SOUTH GROUNDWATER VOC CONCENTRATION CROSS SECTION A-A'

INTERIM REMEDIAL ACTION FOCUSED FIELD INVESTIGATION REPORT, OPERABLE UNIT 4

NAVAL TRAINING CENTER ORLANDO, FLORIDA

8519-08-X04 FIG 4-4 110696MAW



Total Chlorinated VOCs

Avg. Conc = 8,800 ppb (Incl. D010)

Avg. Conc = 647 ppb (w/o D010)

Median Conc. = 244 ppb

Worst Case Assume 8,800 ppb

Area = $(40)(188) + (50)(88) + \frac{1}{2}(40)(18) = 12{,}280\ ft^2$

Assume Sediment Thickness = 1 foot

$$\left(\frac{8{,}800\ \mu g}{kg}\right)\left(\frac{kg}{2.2\ lb}\right)\left(\frac{125\ lb}{ft^3}\right)\left(12{,}280\ ft^3\right)\left(\frac{1\ g}{10^6\ \mu g}\right)\left(\frac{lb}{454\ g}\right)$$

$= 13.5$ lbs

LAKE DRUID CHLORINATED VOCs

ID	VC	1,2-DCE	TCE	PCE	TOTAL
D002		110	220	92	422
D003		92	150	1.6	243.6
D006	95	750	27		872
D010	13	500	53000	94000	147513
D011	1.3		38	3.6	42.9
D012	53	3000	1400	43	4496
D013		700	360	22	1082
D014		53	72	1.8	126.8
D015		38	56	1.4	95.4
D018		7.9	10	20	37.9
D019	1.5	160	800	78	1039.5
D020		3	9		12
D021		36	410	18	464
D022			6.6	200	206.6
D023		31	3.9		34.9
D024		41	100	1400	1541
D025		20	42	4.4	66.4
D026		80	130		210
Avg #1	33	350	3160	6850	8800
Avg #2	38	340	225	145	647

Avg #1 Includes Sample D010

Avg #2 Does Not Include Sample D010

FINAL DRAFT

INFORMATION FOR EVALUATION OF INTERIM REMEDY OPERABLE UNIT 4 INTERIM REMEDIAL ACTION

NAVAL TRAINING CENTER, ORLANDO

Unit Identification Code: N65928

Contract No.: N62467-89-D-0317/107

Prepared by:

ABB Environmental Services, Inc.
2590 Executive Center Circle, East
Tallahassee, Florida 32301

Prepared for:

Department of the Navy, Southern Division
Naval Facilities Engineering Command
2155 Eagle Drive
North Charleston, South Carolina 29418

Barbara Nwokike, Code 1873, Engineer-in-Charge

May 1997

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Information for Evaluation of Interim Remedy
Operable Unit 4 Interim Remedial Action
Naval Training Center, Orlando

1.0 REFINEMENT OF SITE CONCEPTUAL MODEL

1.1 CONTAMINANT MASS BALANCE CALCULATIONS. A major aspect of the Operable Unit (OU) 4 discussion during the November Orlando Partnering Team (OPT) meeting focused on the contribution of dissolved contaminants in groundwater to the surface water contamination observed in Lake Druid. Billy Hall noted that his preliminary calculations indicated an insignificant amount of contaminants were entering Lake Druid through groundwater, and that considerably more mass was present in the lake than would have been expected to accumulate from groundwater inflow.

ABB Environmental Services, Inc. (ABB-ES) has evaluated the mass of contaminants in the groundwater and the lake sediment in greater detail. Based on this evaluation, it appears that the total mass of volatile organic compounds (VOCs) in Lake Druid sediment (1 to 5 pounds) is much less than the mass entering Lake Druid on a yearly basis (24 pounds). Concentrations of volatile organic compounds (VOCs) in Lake Druid sediment can be reasonably attributed to the inflow of contaminated groundwater.

This evaluation is discussed in greater detail below.

1.1.1 Groundwater Our preliminary calculations indicate that total VOCs entering Lake Druid via groundwater are approximately 24 pounds per year. This value is based on average contaminant concentrations in the plume and the cross-sectional area of the plume as shown on Figure 4-4 of the Interim Remedial Action (IRA) Focused Field Investigation Report for OU 4.

The shallow portion of the plume with total VOCs greater than 1,000 micrograms per liter ($\mu g/\ell$) was considered separately from the portion of the plume where VOC concentrations are between 1,000 $\mu g/\ell$ and 100 $\mu g/\ell$. The high concentration portion of the plume is shown in red on Figure 4-4. The cross-sectional area of this portion of the plume is approximately 840 square feet. VOC concentrations measured in groundwater during the direct push program were used to calculate the average concentration of each constituent. The average total VOC concentration is approximately 1,250 $\mu g/\ell$, including 22 $\mu g/\ell$ tetrachloroethene (PCE), 590 $\mu g/\ell$ trichloroethene (TCE), and 635 $\mu g/\ell$ cis-1,2-dichloroethene (DCE). The Darcy velocity was used to represent groundwater flow rates for this calculation. The Darcy velocity (0.39 feet per day [ft/day]) is the product of the hydraulic conductivity (32.7 ft/day, from the pumping test) and the natural hydraulic gradient of 0.012. Note that the hydraulic gradient has been revised downward slightly from the value of 0.017 reported in the Draft OU4 Focused Feasibility Study. The above values were used to calculate a total mass flow of approximately 9 pounds per year (lb/year) total VOCs entering Lake Druid from the shallow high concentration zone.

Because the size of the portion of the plume where VOC concentrations are between 100 $\mu g/\ell$ and 1,000 $\mu g/\ell$ is much greater than the high concentration portion, total VOCs entering Lake Druid from this deeper, lower concentration zone are greater (approximately 14 lb/year) than the amount from the shallow "hot" zone. Again referring to Figure 4-4 of the IRA Focused Field Investigation Report, the cross-sectional area of this zone (shown in blue) is approximately 4,500 square feet. The average total VOC concentration is 355 $\mu g/\ell$, including 153 $\mu g/\ell$ PCE, 102 $\mu g/\ell$ TCE, and 100 $\mu g/\ell$ cis-1,2-DCE.

The zone where VOC concentrations are between 10$\mu g/\ell$ and 100 $\mu g/\ell$ (Figure 4-4, shown in yellow) was also considered. However, the size and shape of this zone is somewhat speculative, due to the limited analytical data available in this area. Total VOCs entering Lake Druid from this zone are only 1 lb/year, based on an average total VOC concentration of 19 $\mu g/\ell$ and an area of 7,435 square feet.

It should be noted that these calculations considered only advection and did not consider dispersion, sorption, or degradation of the VOCs. However, the cross section represented by Figure 4-4 is fairly close to the lakeshore, minimizing the effects of dispersion, sorption, and degradation on the results of the calculation.

The total VOCs of 24 lb/year can be put into perspective by converting the TCE and DCE degradation byproducts into PCE equivalents. The 24 lb/year of mixed contaminants is equivalent to 32 lb/year of pure PCE, or approximately 2.3 gallons of pure PCE. This value is entirely reasonable, considering PCE releases from the laundry were likely small in size.

<u>1.1.2 **Lake Druid**</u> Lake sediment data collected during the Focused Field Investigation was used to estimate the total mass of VOCs in Lake Druid sediment. Sediment VOC concentrations (expressed in micrograms per kilogram [$\mu g/kg$] dry sediment) cannot be directly compared to VOC concentrations in groundwater (expressed in $\mu g/\ell$ of water).

Figure 4-2 from the IRA Focused Field Investigation Report presents the range of VOC concentrations in the lake sediment. The highest concentrations were measured in sediment along a 300-foot-long strip of shoreline, extending approximately 40 feet out into the lake, representing an area of 12,300 square feet (ft^2). Typical concentrations ranged from 100 $\mu g/kg$ to 1,000 $\mu g/kg$. However, total VOC concentrations of 4,500 $\mu g/kg$ and 147,000 $\mu g/kg$ were detected at two locations.

A total of 18 sediment analyses performed within the 12,300 ft^2 zone were averaged to arrive at an average total VOC concentration of 8,800 $\mu g/kg$. This average includes the two very high samples and is, therefore, likely biased high with respect to the actual average concentration in this portion of the lake, excluding the 147,000 $\mu g/kg$ sample, would reduce the average total VOC concentration to 647 $\mu g/kg$. The median concentration of the 18 samples was 244 $\mu g/kg$.

The total mass of VOCs in Lake Druid sediment was calculated using the average concentration of 8,800 $\mu g/kg$, an average dry sediment density of 125 pounds per cubic foot (lb/ft^3), and a sediment thickness of 1 foot across the 12,300 ft^2 area (total volume of 12,300 ft^3). This calculation yields a total mass of VOCs in Lake Druid sediment of approximately 13.5 pounds.

A calculation excluding the 147,000 $\mu g/kg$ sample and using the average VOC concentration of 647 $\mu g/kg$ would yield a total mass of 1 pound of VOCs in Lake Druid sediment. Considering possible variations in the volume of contaminated sediment and the difficulties associated with accurately sampling a heterogenous media such as saturated sediment, we believe a reasonable range for the total mass of VOCs in Lake Druid sediment is between 1 and 5 pounds.

Admittedly, there are numerous assumptions made to calculate the masses of VOCs in groundwater and sediment, each contributing to the uncertainty of the calculations. However, we attempted to perform the calculations conservatively.

Rather than focus on minor variations of each calculation, it is more important to consider what general conclusions can be drawn. We believe that these results show that the major contributor to the VOC contamination in Lake Druid is groundwater, and that the mass of contaminants measured in the sediment could easily be explained by sorption from the contaminated groundwater discharging through the bottom of Lake Druid.

2.0 TECHNOLOGY IDENTIFICATION MATRIX

The OPT has requested a qualitative evaluation of potential technologies that could be used for the *interim* remedy at OU 4. The following table represents this evaluation. Following this matrix are descriptions of each technology. These descriptions provide the justification (for the *interim* remedial action alternative) for the qualifers presented in the matrix table.

	Overall protection of human health and the environment	compliance with ARARs	** Long-term effectiveness and permanence	Short Term Effectiveness	reduction of toxicity, mobility, and volume of contaminants through treatment	* Overall Cost for one year of operation	O&M, Site Monitoring and Reporting Cost for one year of operation.	Consistent with Final Remedy	Regulatory/State Acceptance	Implementability	Status-(F)ull or (P)ilot Scale	Community Acceptability	Time To Implement
GROUNDWATER													
Groundwater Extraction and Treatment	O	O	O	O	O	177k to 212k	112k	O	★	★	F	O	2 to 5 mo
Air Sparging	O	O	O	O	O	173k to 320k	104k	O	Ø	O	P	O	4 to 6 mo
In-Situ/In Well Stripping	★	★	★	O	★	200k	62k	★	O	O	P - F	O	4 to 5 mo
SURFACE WATER/SEDIMENT													
Air Sparging	Ø	O	Ø	O	O	129k	70k	Ø	Ø	O	P - F	Ø	3 to 4 mo
Enhanced Bio-Treatment	O	O	★	O	★	later	later	★	O	O	P	★	4 to 5 mo
Phytoremediation	O	O	★	Ø	★	later	50k	★	O	O	P	O	4 to 5 mo
Natural Attenuation	Ø	O	★	Ø	O	monitoring only	50k	★	Ø	★	F	Ø	2 mo

Good ★
Average O
Below Average Ø

* Overall costs ranges based on permanent versus temporary installations and equipment previously purchased for the site, costs include planning, construction, permitting, O&M for one year, sampling and monitoring, and reporting.

** All surface water/sediment alternatives are considered to be combined with source control

3.0 TECHNOLOGY DESCRIPTIONS

The following pages provide a description of technologies listed on the Technology Evaluation Matrix. Specifically, justification for qualifers presented in this table are discussed. It should be noted that specific locations of wells or equipment that would be installed if any of these technologies were implemented at OU 4 would be decided during the design phase.

Descriptions of the following technologies for groundwater and surface water/sediment are provided:

Information for Evaluation of Interim Remedy
Operable Unit4 Interim Remedial Action
Naval Training Center, Orlando

Groundwater	Surface Water/Sediment
Groundwater Extraction and Treatment	Natural Attenuation
Air Sparging	Enhanced Bioremediation
In-Well Air Stripping	Phytoremediation
	Air Diffusion/Sparging

GROUNDWATER - GROUNDWATER EXTRACTION AND TREATMENT

System Type:

- Previously piloted via pumping test
- Full-scale treatment system

Compc..ents:

- Groundwater extraction via pumping well(s)
- Treatment of extracted groundwater via air stripping
- Discharge to Orlando Sewage Treatment Plant

Operational Criteria:

- One-year operation (or until final remedy for OU 4 is identified)
- Groundwater, surface water, and sediment sampling and analysis
- System operation, maintenance, and monitoring

Description of Major Components:

Hydraulic Control

- Hydraulic control of contaminated groundwater will be achieved through extraction using recovery well(s).

- The extraction system will likely consist of one or two recovery wells and will be positioned upgradient of Lake Druid, within the central portion of the plume, where the greatest mass removal of contaminants in the surficial aquifer can be achieved.

- It is recognized that some portion of contaminated surficial aquifer groundwater, beyond the point of stagnation of the extraction system, would continue to migrate to the lake. However, the location of the system would provide for the greatest mass removal of contaminants from the surficial aquifer. The location of the extraction system and its corresponding operational parameters will be evaluated during the design to minimize the amount of contaminated groundwater that would continue to migrate to the lake.

- Recovery wells will be connected via manifold and conveyance piping to the groundwater treatment system.

Air Stripping

- Air stripping would be accomplished using low profile forced aeration tray stripping.

- This technology would treat chemicals in groundwater to limits acceptable by the Orlando Sewage Treatment Plant (STP).

- It is estimated that a four-tray low profile forced aeration stripper with an air flow rate of 900 cubic feet per minute (cfm) and a minimum air to water ratio of 67.3 would be effective in reducing the concentrations of chemicals in extracted groundwater.

- Based on preliminary calculations to estimate the concentration of VOCs in the off-gas from the air stripper, it is not anticipated that off-gas treatment is necessary. However, samples of organic vapors from the air stripper would be collected and analyzed for VOCs on a regular basis, thereby providing a means to evaluate whether or not off-gas treatment were to become necessary.

- If treatment of the off-gas were to become necessary, vapor-phase granular activated carbon (GAC) could be used to treat VOCs to acceptable levels. At least two GAC canisters, connected in series, would be installed at the exhaust from the air stripper. A stack would then be installed after the second GAC canister to adequately disperse the treated exhaust.

Treated Groundwater Discharge

- Treated groundwater from the low profile tray air stripper would be discharged to the Orlando STP.

- As defined in the Clean Water Act, the discharge would adhere to all general prohibitions (i.e., the introduction of contaminants to the POTW would not cause interference with the operation of the POTW, and would not pass through the system) and specific prohibitions (i.e., would not create a fire or explosion hazard in the sewer or POTW, would not cause corrosive damage to the POTW, and would not obstruct the flow of water to the POTW).

- Effluent from the air stripper would be sampled and analyzed for water quality parameters, such as biochemical oxygen demand (BOD), pH, and total suspended solids. While it is not anticipated that treatment of extracted water for these parameters is necessary, effluent from the air stripper would be monitored for these parameters to ensure compliance.

Groundwater, Surface Water, Sediment, and System Monitoring

- Monitoring of groundwater, surface water, sediment, the influent and effluent to the treatment system, and off-gas of the air stripper would occur on a biweekly basis for the first month, then monthly for the next 5 months, and then bimonthly until the end of the anticipated operational period for the system (i.e., 1 year).

- Samples collected during the monitoring program would be analyzed for TCL analytical parameters and biological parameters as well. Additional parameters may be added, as necessary. Data would be used to evaluate the migration of contaminated groundwater and to assess whether or not contaminant concentrations in surface water and sediment samples from the lake were decreasing.

- Data would be summarized and managed on a quarterly basis.

- In addition to these monitoring activities, the effectiveness of the treatment system and the operation of the low profile tray stripper will also be monitored on a continual basis. Proposed monitoring will include influent and effluent sampling and analysis, liquid and air flow measurements, and other process monitoring requirements.

Evaluation:

Overall Protection of Human Health and the Environment

- Hydraulic control over the portion of the aquifer with total VOC concentrations greater than 100 $\mu g/\ell$ should be obtained if this option were implemented. Groundwater containing VOCs and other contaminants would be extracted, thus reducing the mass of contaminants available for discharge to Lake Druid.

- VOCs in the extracted groundwater would be reduced through treatment via air stripping, with further treatment provided by the Orlando STP.

- Based on data collected to date at the OU, the implementation of this alterative will not have adverse short-term or cross-media (i.e., contaminate other media) effects.

- Contaminated groundwater downgradient of the capture zone would discharge to Lake Druid until that area is flushed. For this period of time, the potential risk to humans exposed to surface water via swimming would remain.

Compliance with Applicable or Relevant and Appropriate Requirement (ARARs)

- If this technology were implemented, compliance with ARARs would be achieved.

- A permit would most likely not be necessary for the air stripper because the stripper would be considered a small source in operation for less than 5 years.

Long-Term Effectiveness and Permanence

- This alternative does offer a long-term and permanent remedy for groundwater remediation without relying on natural transformation processes (as long as the source of groundwater contamination is also addressed); however, this technology is not preferred as the final remedy.

- Extraction of groundwater removes contaminated groundwater within the capture zone of the extraction wells, thus reducing the available mass of VOCs and other contaminants in groundwater that would eventually discharge to Lake Druid.

- Pretreatment of extracted groundwater via air stripping and further treatment at the Orlando STP will reduce VOC and other contaminant concentrations in extracted groundwater.

- Groundwater, surface water, and sediment monitoring would provide a means of evaluating the concentrations of contaminants in these media over the IRA timeframe (i.e., 1 year or until final remedy for OU 4 is identified) and would provide a means of evaluating the effectiveness of the alternative.

- All controls proposed in this alternative are considered reliable.

Reduction of Toxicity, Mobility, and Volume of Contaminants Through Treatment

- This alternative would permanently reduce the toxicity, mobility, and volume of VOCs and other contaminants in extracted groundwater.

- VOCs will be treated via air stripping, and the off-gas from the air stripper would be monitored to determine whether or not collection and treatment via GAC is necessary.

- The treated groundwater would be discharged to the Orlando STP for further treatment of VOCs and treatment of other contaminants.

Short-Term Effectiveness

- By implementing this alternative, the migration of groundwater contamination to Lake Druid would be affected as soon as the system is brought on-line. Contaminated groundwater within the capture zone would be extracted, thereby mitigating further migration from the "hot zone."

- Installing an extraction well, treating the groundwater, and discharging to the Orlando STP should not pose a significant risk to workers or the community.

- Workers who may install or operate the treatment system may be exposed to unacceptable risks that have not yet been quantified.

Implementability

- Construction of the extraction and treatment system is relatively easy to implement because one extraction well already exists at the site.

- Construction of the treatment system would not pose a threat to workers or the community.

- Components of the proposed system are readily available (i.e., off-the-shelf products).

Cost

- Total direct costs are estimated to be approximately $65,000 to $100,000.

- Total operations and maintenance (O&M) and monitoring costs (for 1 year) are estimated to be $112,000.

- The total cost for this alternative, including additional site monitoring and reporting requirements is estimated to be $177,000 to $212,000.

Consistency with Final Remedy

- Other remedies will be considered for long-term remediation at OU 4.

- Implementation of this alternative may be consistent with the final remedy if source control is initiated.

Regulatory/State Acceptance

- EPA and FDEP have indicated that groundwater extraction and treatment is an acceptable remedy for the OU 4 IRA.

Community Acceptance

- Community concerns for implementation of this technology at OU 4 are not anticipated.

GROUNDWATER - AIR SPARGING

Definition:

Air sparging is used to remove VOCs from groundwater without extracting the water. Air is injected into the saturated zone to create turbulence and volatilize organic compounds. As air moves up through the aquifer, contaminants partition into the gas phase and are then extracted as organic vapors from the vadose zone or allowed to escape through the vadose zone into the atmosphere.

System Type:

- Pilot-scale system to ensure effectiveness
- Use observational approach to bring system to full scale

Components:

- Install horizontal or vertical air injection wells
- Construct blower system at well head(s)
- Inject air into subsurface

Operational Criteria:

- One-year operation (or until final remedy for OU 4 is identified)
- Groundwater, surface water, and sediment sampling and analysis
- System operation, maintenance, and monitoring

Description of Major Components:

Pilot Test

- Prior to installing an air sparging system at OU 4, a pilot test should be conducted to obtain design criteria for the alternative and evaluate the technical feasibility of an air sparging system.

- Specifically, the pilot test would include

    - estimating the efficiency of removal of VOCs from groundwater;
    - evaluating the potential for the water table to mound and the affects of this occurrence;
    - estimating VOC emission rates from the aquifer;
    - predicting and evaluating the path of air flow in the subsurface to assess the possibility of air migrating horizontally in the subsurface beneath the hard layer;
    - evaluating changes in aquifer characteristics (the effective porosity to water flow is reduced when air is introduced to the subsurface, or when there is a mixture of liquid and gas phases in the aquifer, and this may reduce the hydraulic conductivity); and
    - identifying the number of sparge wells and soil vapor extraction (SVE) wells that are necessary (i.e., determine the radius of influence of individual air sparging wells).

Install Air Sparging System

- It is anticipated that the air sparging system for OU 4 would be installed to a depth of 15 feet (or the depth of contamination).

- Either vertical or horizontal air injection wells could be installed. It is assumed that vertical wells would be installed during the IRA.

Soil Vapor Collection

- SVE is typically used to control off-gas generated by air sparging. Typically, vapor extraction wells or trenches are installed above the water table in a configuration to capture vapors generated from air sparging.

- At OU 4, the thickness of the unsaturated zone is less than 1.5 feet (in some places) and, therefore, the effectiveness of SVE in a limited vadose zone is questionable.

- SVE is, therefore, not a component of an air sparging system for OU 4.

Groundwater, Surface Water, Sediment, and System Monitoring

- Groundwater samples would be collected to evaluate the effectiveness (i.e., percent removal) of the air sparging system.

- The ambient atmosphere would be monitored in the vicinity of the system (i.e., over the top of the air sparging area) and at the property line to identify whether or not vapors released to the atmosphere are at a level of concern to human health or the environment.

- Surface water and sediment samples would be collected on a monthly basis from the shoreline of Lake Druid and analyzed for total VOCs and other biological parameters. The analytical results would be reviewed to evaluate whether or not the concentrations of VOCs in the Lake were decreasing over time due to the implementation of air sparging.

Evaluation:

Overall Protection of Human Health and the Environment

- The use of air sparging may potentially cause risks not associated with other interim remedial technologies (such as groundwater extraction). Air injection can enhance the undesirable offsite migration of vapors to the condominiums adjacent to the site. A preliminary assessment of these potential risks from VOCs in the air from the air sparging technology was performed. Preliminary calculations were made to determine an acceptable level of VOCs in the ambient air that would not cause an excess cancer risk greater than 10^{-6}. These calculations indicate that it is unlikely that the air sparging treatment technology would cause an unacceptable risk to residents of the condominiums adjacent to the site. (These calculations are presented in the pages following the evaluation section for air sparging).

Compliance with ARARs

- A permit would be required if air sparging were installed in the wetland area. The permit, a minimum activity permit, would be required, and is relatively easy to obtain.

Long-Term Effectiveness and Permanence

- Because the transfer of dissolved contaminants from groundwater to air occurs in subsurface conditions and laboratory simulation is difficult, conclusions regarding the path of subsurface air flow are based on limited laboratory-scale studies and field testing systems. Two theories have been proposed to describe the subsurface air flow: air flows in a stream of discrete air bubbles, or air flows in continuous air channels. As air enters the saturated zone, it creates hydraulic voids or "cavitation." These voids can occur in the form of bubbles or channels. The form of cavitation that occurs is primarily a function of grain size, shape, homogeneity, porosity, and other subsurface media characteristics. Laboratory observations indicate that air flow through porous media, such as coarse sand and gravel (greater than 4 millimeter [mm] in diameter) occurs through air bubbles that rise to the top of the water column. Conversely, air flow through fine media, such as fine sand, silt, and clay (less than 0.75 mm in diameter) occurs through streams or air channels. It is estimated that, given the fine sand present at OU 4, the potential exists for air channels to develop. This is important because the channeling reduces the air contact surface area to groundwater and aquifer material, which reduces the mass transfer of VOCs and oxygen and ultimately may reduce the effectiveness of this technology.

- The presence of the hard layer raises questions as to where the air bubbles or channels may escape and the affect this may have on groundwater flow in the area. As far as migration of the air bubbles or channels, some air may migrate through the hard layer. Otherwise, it is possible that air may accumulate below the hard layer and migrate horizontally until it can escape into the vadose zone. This is a concern because contaminated air migrating along the hard layer to the fenceline could potentially introduce contamination to that area.

- When air is injected into the subsurface through a well(s), convection currents form that circulate the groundwater in the vicinity of the well. These currents form due to the density differences between the air/water mixture and the groundwater farther away from the well. This action may create groundwater upwelling near the air sparging locations. At OU 4, the groundwater table is only approximately 1.5 feet below land surface (bls), and it is possible that the upwelling effect may present itself as a pool of water on the ground surface. If this occurs, the potential exists for human and ecological receptors to be in direct contact with the contaminated groundwater and the contamination of soil in that area.

Reduction of Toxicity, Mobility, and Volume of Contaminants Through Treatment

- Technology would most likely reduce concentrations of VOCs in groundwater through volatilization.

- Technology may not reduce concentrations of VOCs to below Florida surface water standards.

Short-Term Effectiveness

- Technology would most likely be effective in the short term because volatilization and gas transfer is a relatively rapid treatment.

Implementability

- Installation of air sparging wells near the lakeshore may be difficult due to the physical environment in the area. Most likely, the injection wells cannot be installed via a hand auger; hand augering to this depth was attempted during the Focused Field Investigation, but the borehole would not remain open. Jet rotary installation of the wells should be considered; however, this method may create a zone around the well for preferential migration pathway for contaminated air.

- Construction of the treatment system in the wetland area may require a permit.

- Components of the proposed system are readily available (i.e., "off-the-shelf" products).

Cost

- Total direct costs are estimated to be approximately $68,500 to $216,000.

- Total O&M and monitoring costs (per year) are estimated to be $104,000.

- The total cost for this alternative is, therefore, estimated to be $172,500 to $320,000.

Consistency with Final Remedy

- Air sparging is a viable candidate for adaptation to the selected long-term remedy for OU 4.

- Air sparging in the source area (once that area is defined) will be considered in the overall RI/FS.

Regulatory/State Acceptance

- U.S. Environmental Protection Agency (USEPA) and Florida Department Environmental Protection (FDEP) have raised concerns regarding the use of this technology at the lakeshore. Specifically, the impact of air sparging to the wetlands and the effectiveness of reducing contaminant concentrations to levels below Florida surface water standards.

Community Acceptance

- Community concerns regarding implementation of this technology at OU 4 are not anticipated.

Calculations for Human Health Risk Estimates Based on Implementation of Air Sparging:

Using a target risk level of 10^{-6}, acceptable ambient air concentrations were calculated using the following equation:

ambient concentration = target risk level / inhalation unit risk

The results of the these calculations are presented below for the chemicals of potential concern:

Chemical	Inhalation Unit Risk $(\mu g/m^3)^{-1}$	Target Ambient Air Concentration $(\mu g/m^3)$
Trichloroethylene (TCE)	1.7×10^{-6}	0.6
Tetrachloroethene (PCE)	5.8×10^{-7}	1.7
Vinyl Chloride	8.4×10^{-5}	0.01

Note: $\mu g/m^3$ = micrograms per cubic meter.

The target ambient air concentration was then used in a simple linear box model with site-specific information to determine an acceptable daily emission rate (a daily emission rate that would not result in an excess cancer rate). The box model equation is:

$$c = B + (q * W) / (u * H);$$

where,

- c = ambient air concentration (target ambient air concentration calculated above),
- B = background volatile organic compound concentration (assumed to be zero),
- q = emission rate,
- W = width of the site (longest side of site - estimated at 122 meters (400 feet),
- u = wind speed (6 m/s - mean annual wind speed through the mixing layer for Florida), and
- H = mixing height (a standard default value - 2 meters roughly a man's height).

The calculated acceptable emission's rate for each chemical of concern is presented below:

Chemical	Target Ambient Air Concentration $(\mu g/m^3)$	Acceptable Emission Rate $(\mu g/s)$	Acceptable Emission Rate (g/d)	Acceptable Emission Rate (lbs/year)
Trichloroethylene (TCE)	0.6	878	76	61
Tetrachloroethene (PCE)	1.7	2489	215	173
Vinyl Chloride	0.01	15	1.3	1

Notes: $\mu g/m^3$ = micrograms per cubic meter. g/d = grams per day.
$\mu g/s$ = micrograms per second. lbs/year = pounds per year.

Preliminary mass balance calculations (see part 1 of this evaluation packet) indicate that groundwater contributes VOCs to the surface water. If the same plume dimensions are considered in the evaluation of the air sparging technology, then approximately the same amount of contamination will contact the air sparging wells in a year. Therefore, based on these calculations it is not likely that TCE or PCE would contribute to an excess cancer lifetime risk of greater than 10^{-6}. Additionally, since vinyl chloride was not detected in the groundwater (vinyl chloride was detected in surface water), and TCE degrades to vinyl chloride in anaerobic conditions, it is unlikely that vinyl chloride would be a concern while using the air sparging technology.

GROUNDWATER - UVB/*IN SITU* IN-WELL AIR STRIPPING

System Type:

- Pilot-scale system
- Use operational approach to bring system to full scale
- Pumping test data (already available) may lead to full scale operation

Components:

- *In situ* containment/remediation of the groundwater VOC plume through UVB technology
- Install UVB well and UVB system

Operational Criteria:

- May be operated through closure
- Surface water, sediment, and groundwater sampling and analysis
- System operation, maintenance, and monitoring
- One-year operation (or until final remedy for OU 4 is identified)

Description of Major Components:

- *In situ* containment of groundwater is established through a specialized well which creates a circulation sphere within the aquifer. The dimensions of the circulation sphere are dependent on site specific conditions (i.e. hydraulic conductivity, gradient, saturated thickness, recirculation rates, etc.). Part of the groundwater entering the specialized well represents new upstream waters that enter through the upgradient capture zone, while an equal treated portion exits the sphere through the downgradient release zone.

- The vertical circulation sphere in the saturated zone is established by creating a pressure differential, with a pump and/or vacuum blower, across two screens in the specialized well. In the ordinary mode of operation, groundwater enters the well through the upper screen and leaves through the lower screen.

- While traveling through the specialized well, the groundwater passes through an in-well treatment system which includes an air stripper/aerator. The volatilized VOCs are subsequently transported through the well and up to the off-gas treatment unit or to the atmosphere, by means of the vacuum blower.

- Cosubstances, such as nutrients, may be added through the circulating process within the specialized well to further facilitate *in situ* biodegradation of contaminants in the aquifer.

- Vertical circulation flow (i.e., *in situ* remedial sphere) allows for both vertical and horizontal containment/treatment of the affected aquifer.

Evaluation:

Overall Protection of Human Health and the Environment

- *In situ* containment and treatment of the portion of the aquifer with total VOC concentrations greater than 100 $\mu g/\ell$ should be obtained with one well were this option to be implemented. Groundwater containing VOCs would be contained and treated *in situ* through the vertical circulation sphere via in-well stripping.

- VOC off-gasses can be can be captured and treated, if necessary.

- By implementing this technology, no adverse short-term or cross-media effects are anticipated.

Compliance with ARARs

- This alternative may comply with chemical-specific ARARs (Florida surface water standards) in the short term.

- Compliance with location-specific ARARs (such as those governing the wetlands or the lake ecosystem) is apparent; however, evaluation would be ongoing.

- A permit would be required if this technology were installed in the wetland area. The permit, a minimum activity permit, would be required and is relatively easy to obtain.

- A permit would most likely not be necessary for the air stripper because the stripper would be considered a small source in operation for less than 5 years.

Long-Term Effectiveness and Permanence

- Implementation of this alternative would have long-term effectiveness due to its ability to contain and remediate the aquifer.

- Once the source area is defined, this technology could also be used in the source area.

Reduction of Toxicity, Mobility, and Volume of Contaminants Through Treatment

- This alternative will reduce toxicity, mobility, and volume of VOCs migrating to the surface water.

- Groundwater VOCs will be treated via in-well stripping, any off-gas would be monitored to determine whether or not collection and treatment is necessary.

Short-Term Effectiveness

- By implementing this technology, the migration of groundwater with VOC concentrations to Lake Druid would be affected immediately. Contaminated groundwater would be contained and treated *in situ*, thereby mitigating further migration.

- *In situ* treatment of the groundwater should not pose a significant risk to workers or the community.

- Workers who may install or operate the treatment system may be exposed to unacceptable risks that have not yet been quantified.

Implementability

- Construction of the UVB system should be relatively easy to implement.

- Components of the proposed system are proprietary.

Cost

- Direct cost is estimated to be $138,000.

- Site O&M and monitoring costs are estimated to be $62,000 per year. May be a shared cost with any sediment treatment option.

- Reporting costs are estimated at approximately $200,000.

Consistency with Final Remedy

- Would be consistent with long-term/final remedy chosen.

Regulatory/State Acceptance

- EPA and FDEP seem favorable regarding implementation of this technology at OU 4 as the interim remedy.

Community Acceptance

- Community concerns regarding implementation of this technology is anticipated to be favorable.

SURFACE WATER/SEDIMENT - NATURAL ATTENUATION

System Type

- None (monitoring only)

Components

- Control of contaminated groundwater entering the lake to eliminate contaminant source

Operational Criteria

- One-year operation (or until final remedy for OU 4 is identified)
- Surface water and sediment sampling and analysis

Description of Major Components

Hydraulic Control

- Control of the contaminants entering the lake will be achieved during the IRA through use of a groundwater treatment technology. The evaluation of these technologies is included elsewhere in this report.

Surface Water and Sediment Sampling and Analysis

- Preliminary sediment sampling during the focused field investigation indicated anaerobic conditions were present in the lake sediments. Anaerobic bacteria appear to be degrading the chlorinated solvents, based on the generation of vinyl chloride in the lake.

- This technology assumes control of contaminants migrating into the lake, effectively eliminating the primary source of lake contamination. Therefore, continued degradation of VOCs in lake sediment should gradually remediate the lake until Florida surface water standards are no longer exceeded. This evaluation (for costing purposes) assumes 1 year of lake monitoring (or until the final remedy for OU 4 is decided). Actual duration will depend on the rate of contaminant degradation and volatilization, and cannot be predicted at this time.

Groundwater, Surface Water, Sediment, and System Monitoring

- Monitoring of groundwater, surface water, and sediment would occur on a biweekly basis for the first month, then monthly until the end of the anticipated operational period for the system (i.e., 1 year or until the final remedy for OU 4 is decided).

- All samples collected during the monitoring program would be analyzed for target compound list (TCL) analytical parameters. Sediment and surface water will also be monitored for nutrient concentrations, bacterial populations, and degradation byproducts. Additional parameters may be added, as necessary. Data would be used to evaluate biological conditions and to assess whether or not contaminant concentrations in surface water and sediment samples from the lake were decreasing.

- Data would be summarized and managed on a quarterly basis.

Evaluation:

Evaluation of technologies to provide control of contaminants entering the lake through groundwater are provided elsewhere in this report. The following discussion will focus only on natural attenuation in the lake.

Overall Protection of Human Health and the Environment

- Successful implementation of this technology should degrade VOCs present in Lake Druid sediments and gradually reduce VOC concentrations in surface water below Florida standards.

- However, until these concentrations are reduced, the potential for risk to human and ecological receptors based on exposure to surface water and sediment would exist. These risks have not yet been quantified.

Compliance with ARARs

- This alternative may not comply with chemical-specific ARARs (Florida surface water standards) in the short term, as natural attenuation is not likely to immediately reduce concentrations of VOCs in surface water and sediment.

- Compliance with location-specific ARARs (such as those governing the wetlands or the lake ecosystem) would be expected. No actions proposed for this alternative should trigger location-specific ARARs.

Long-Term Effectiveness and Permanence

- Successful implementation of this alternative, combined with control of the source of VOCs to Lake Druid, offers a long-term and permanent remedy for VOC contamination of Lake Druid sediment and surface water.

- Natural biodegradation of the VOCs in the lake sediment would remove the remaining source of VOC contamination in surface water.

- Surface water and sediment monitoring would provide a means of evaluating the concentrations of contaminants in these media over the IRA timeframe (i.e., 1 year) and would provide a means of evaluating the effectiveness of the alternative.

Reduction of Toxicity, Mobility, and Volume of Contaminants Through Treatment

- This alternative would ultimately reduce toxicity, mobility, and volume of VOCs in Lake Druid surface water and sediment.

Short-Term Effectiveness

- Natural biodegradation can be a slow process. Some of the contaminants of concern are known to degrade very slowly under anaerobic conditions. Implementation of this alternative may not result in an immediate decrease in VOC concentrations.

Implementability

- This alternative does not require remedial construction for implementation. Monitoring activities are easily implemented.

Cost

- None. All associated monitoring costs are included in the evaluation of technologies to provide control of contaminants entering the lake through groundwater, provided elsewhere in this report.

Consistency with Final Remedy

- Would be consistent with long-term/final remedy chosen.

Regulatory/State Acceptance

- USEPA and FDEP seem favorable regarding implementation of this technology at OU 4 as part of the interim remedy.

Community Acceptance

- Community concerns regarding implementation of this technology are anticipated to be favorable.

SURFACE WATER/SEDIMENT - ENHANCED BIOREMEDIATION

System Type

- Bench- or pilot-scale system to ensure effectiveness of technology
- Use observational approach to bring system to full scale

Components

- Enhancement of natural biological processes in sediment through injection of nutrients and/or nonindigenous bacteria
- Control of contaminated groundwater entering the lake to eliminate contaminant source

Operational Criteria

- One-year operation (or until the final remedy for OU 4 has been decided)
- Surface water and sediment sampling and analysis
- System operation, maintenance, and monitoring

Description of Major Components

Hydraulic Control

- Control of the contaminants entering the lake will be achieved during the IRA through use of a groundwater treatment technology. The evaluation of these technologies is included elsewhere in this report.

Nutrient/Bacterial Injection

- Preliminary sediment sampling during the focused field investigation indicated anaerobic conditions were present in the lake sediments. Anaerobic bacteria appear to be degrading the chlorinated solvents, based on the generation of vinyl chloride in the lake. This treatment option assumes that continued anaerobic degradation will be encouraged, rather than attempting to establish aerobic conditions in the lake sediment.

- This technology assumes existing conditions are limiting and biodegradation rates can be accelerated through the addition of nutrients, electron donors, and/or bacteria.

- The injection system could consist of a series of well points driven into the lake bottom in the area of highest sediment VOC concentrations. These well points would be manifolded back to an injection pump that would be used to introduce the appropriate amendments into the lake sediment. Amendments could be injected periodically or continuously.

- The location and number of the injection points, as well as the amendments necessary to enhance the natural biodegradation already occurring in the lake, would be determined after conducting additional lake sampling to better evaluate the current bacterial population and environment. Relatively simple bench-scale serum bottle testing may also be required to establish the appropriate mix of nutrients, electron donors, and/or nonindigenous bacteria to inject.

- Enhancement of the current anaerobic degradation process could lead to the increased generation of vinyl chloride, potentially increasing the vinyl chloride concentration in surface water. This could require additional human health and ecological risk evaluations.

- This evaluation of this technology assumes control of contaminants migrating into the lake, effectively eliminating the primary source of lake contamination. Therefore, treatment of the lake sediment is only required until VOC concentrations in the sediment have been reduced to the point where Florida surface water standards are no longer exceeded. This evaluation assumes 1 year of operation (or until the final remedy for OU 4 is decided). Actual duration will depend on the rate of contaminant degradation and volatilization and cannot be predicted at this time.

- Permits will likely be required to install the injection system and to introduce nutrients or bacteria to the lake environment. This requirement is currently under evaluation.

Groundwater, Surface Water, Sediment, and System Monitoring

- Monitoring of groundwater, surface water, sediment, and the injection solution would occur on a biweekly basis for the first month, then monthly until the end of the anticipated operational period for the system (i.e., 1 year or until the final remedy for OU 4 has been decided).

- All samples collected during the monitoring program would be analyzed for TCL analytical parameters. Sediment and the injected solution will also be monitored for nutrient concentrations, bacterial populations, and degradation byproducts. Ambient air monitoring for vinyl chloride may also be required. Additional parameters may be added, as necessary. Data would be used to evaluate biological conditions and to assess whether or not contaminant concentrations in surface water and sediment samples from the lake were decreasing.

- Data would be summarized and interpreted on a quarterly basis.

Evaluation:

Evaluation of technologies to provide control of contaminants entering the lake through groundwater are provided elsewhere in this report. The following discussion will focus only on enhanced bioremediation in the lake.

Overall Protection of Human Health and the Environment

- Successful implementation of this technology should degrade VOCs present in Lake Druid sediments, and gradually reduce VOC concentrations in surface water below Florida standards.

- Adverse short-term effects associated with this alternative could include an increase in vinyl chloride concentrations and damage to the lake ecosystem by the installation of the injection system and the introduction of nutrients.

- Until contaminant concentrations are reduced, the potential for risk to human and ecological receptors based on exposure to surface water and sediment would exist. These risks have not yet been quantified.

Compliance with ARARs

- This alternative may not comply with chemical-specific ARARs (Florida surface water standards) in the short term, as enhanced biodegradation may not immediately reduce concentrations of VOCs in surface water and sediment.

- Compliance with location-specific ARARs (such as those governing the wetlands or the lake ecosystem) cannot be evaluated until permitting issues have been resolved.

- A permit would be required if this technology were installed in the wetland area. The permit, a minimum activity permit, would be required, and is relatively easy to obtain.

Long-Term Effectiveness and Permanence

- Successful implementation of this alternative, combined with control of the source of VOCs to Lake Druid, offers a long-term and permanent remedy for VOC contamination of Lake Druid sediment and surface water.
- Enhanced biodegradation of the VOCs in the lake sediment would remove the potential for VOC contamination in surface water.
- Surface water and sediment monitoring would provide a means of evaluating the concentrations of contaminants in these media over the IRA timeframe (i.e., 1 year) and would provide a means of evaluating the effectiveness of the alternative as the long-term solution for the OU.
- Enhancing natural biodegradation in a lake ecosystem could be considered an unproven technology.

Reduction of Toxicity, Mobility, and Volume of Contaminants Through Treatment

- This alternative would ultimately reduce toxicity, mobility, and volume of VOCs in Lake Druid surface water and sediment. However, initial increases in surface water vinyl chloride concentrations may occur.
- Higher vinyl chloride concentrations in surface water could lead to detectable vinyl chloride concentrations in ambient air.

Short-Term Effectiveness

- Biodegradation can be a slow process. Some of the contaminants of concern are known to degrade very slowly under anaerobic conditions. Implementation of this alternative may not result in an immediate decrease in VOC concentrations.
- Workers who may implement this technology may be exposed to unacceptable risks that have not yet been quantified.

Implementability

- Construction of the nutrient injection system is relatively easy to implement.
- Components of the injection system are readily available.
- Permitting requirements may affect schedule and limit the allowable nutrients or bacteria acceptable for injection into the lake.

Cost

- Total costs will be developed with input from Bechtel during the OU 4 feasibility study.

Consistency with Final Remedy

- Would be consistent with long-term/final remedy chosen.

Regulatory/State Acceptance

- EPA and FDEP seem favorable regarding implementation of this technology at OU 4 as part of the interim remedy.

- However, effects to ecological community and wetlands in the vicinity if nutrients were added should be evaluated.

Community Acceptance

- Community concerns regarding implementation of this technology are anticipated to be favorable.

SEDIMENT/SURFACE WATER - PHYTOREMEDIATION

Definition:

Phytoremediation is the use of plant and tree root systems for the *in situ* environmental remediation of contaminated soil, sediment, and water.

System Type:

- Bench/pilot scale system
- Use operational approach to bring system to full scale

Components:

- Enhance indigenous plant life to treat sediments with high chlorinated VOC concentrations
- Addition of plant life to treat sediments with high chlorinated VOC concentrations
- Control of contaminated groundwater entering the lake to eliminate contaminant source

Operational Criteria:

- Operation through overall remedial investigation and feasibility study (RI/FS) until no further action necessary
- Groundwater, surface water, and sediment sampling and analysis
- Ecological monitoring
- One-year operation (or until the final remedy for OU 4 has been decided)

Description of Major Components:

Hydraulic Control

- Control of the contaminants entering the lake will be achieved during the IRA through use of a groundwater treatment technology. The evaluation of these technologies is included elsewhere in this report.

Phytoremediation

- Phytoremediation will be driven through research by the USEPA in conjunction with the University of Georgia (UGA).

- Laboratory and onsite research by the UGA will determine the method for initiating phytoremediation. Initiation will be through either the enhancement of the native plant life or the addition of plants that have been proven to successfully remediate the contaminants of concern. (Samples were provided to UGA on Nov. 11, 1996.)

- Phytoremediation is an innovative treatment technology, meaning that the technology has been tested and used for treatment of hazardous wastes; however, it is lacking well-documented cost and performance data under a variety of conditions. To date, the majority of the full scale treatment system data is from the treatment of metals and munition wastes. Information regarding full-scale remediation of chlorinated solvents using phytoremediation is still limited. Ongoing analysis by UGA will be the major component in determining the phyto-remedial strategy for OU 4.

Groundwater, Surface Water, Sediment and Eco-System Monitoring

- Monitoring of groundwater, surface water, and sediment will occur on a biweekly basis for the first month, then monthly until the end of the anticipated operational period.

- Monitoring schedules specific to phytoremediation will be decided by UGA.

- All samples collected during the monitoring program would be analyzed for TCL analytical parameters. Sediment and surface water will also be monitored for nutrient concentrations, bacterial populations, and degradation byproducts. Additional parameters may be added, as necessary. Data would be used to evaluate biological conditions and to assess whether or not contaminant concentrations in surface water and sediment samples from the lake were decreasing.

Evaluation:

Evaluation of technologies to provide control of contaminants entering the lake through groundwater are provided elsewhere in this report. The following discussion will focus only on phytoremediation along the lake shore and in the lake.

Overall Protection of Human Health and the Environment

- Implementation of this technology will most likely reduce mass of contaminants in the sediment over time. Remediation timeframe will be determined through research.

- Any ecological effects due to the addition of new plant life or the enhancement of indigenous life needs to be identified and evaluated and is deferred to UGA research.

- Until contaminant concentrations are reduced, the potential for risk to human and ecological receptors based on exposure to surface water and sediment would exist. These risks have not yet been quantified.

Compliance with ARARs

- This alternative may not comply with chemical-specific ARARs (Florida surface water standards) in the short term because phytoremediation is not likely to immediately reduce concentrations of VOCs in the surface water and sediment.

- Compliance with location-specific ARARs (such as those governing the wetlands or the lake ecosystem) may not be possible; however, this is currently being evaluated).

- A permit would be required if this technology were installed in the wetland area. The permit, a minimum activity permit, would be required, and is relatively easy to obtain.

Long-Term Effectiveness and Permanence

- Successful implementation of this alternative, combined with control of the source of VOCs to Lake Druid, offers a long-term and permanent remedy for sediment remediation.

- Long-term effectiveness data at other similar sites are not available at this time. Long-term effectiveness and permanence will be evaluated during research by UGA.

Reduction of Toxicity, Mobility, and Volume of Contaminants Through Treatment

- This alternative should permanently reduce toxicity, mobility, and volume of VOCs in sediment, and may possibly have an effect on the surface water VOCs.

- VOC contaminants will be phytodegradated, bio-treated through enhanced mineralization in the rhizosphere, and/or directly taken up by plants acting as organic pumps.

Short-Term Effectiveness

- Achieving optimum performance of phytoremediation may take time; therefore, effectiveness in the short term is questionable.

- Workers who may implement this technology may be exposed to unacceptable risks that have not yet been quantified.

- Natural biodegradation can be a slow process. Some of the contaminants of concern are known to degrade very slowly under anaerobic conditions. Implementation of this alternative may not result in an immediate decrease in VOC concentrations.

Implementability

- Based on the variety and growth rate of existing plant life at the site, implementation may be relatively easy; however, implementability will also be evaluated by UGA.

Cost

- Direct cost will be identified through UGA.

- Site monitoring costs may depend largely on UGA but are estimated to be approximately $50,000 per year. Much of this cost may be shared with any groundwater treatment option.

- Reporting costs will depend largely on UGA.

Consistency with Final Remedy

- Should be consistent with any final solution.

Regulatory/State Acceptance

- USEPA and FDEP seem favorable regarding implementation of this technology at OU 4 as part of the interim remedy.

- However, effects to ecological community and wetlands in the vicinity should be evaluated.

Community Acceptance

- Negative community concerns regarding implementation of this technology at OU 4 are not anticipated.

SURFACE WATER/SEDIMENT - AIR DIFFUSION/SPARGING

System Type:

- Pilot-scale/full-scale system
- Use operational approach to bring system to full scale

Components:

- Install piping system with compressor(s)
- Diffuser system installed on top of sediment organic mat present at site

- Surface water air sparging through air diffuser system
- Control of contaminated groundwater entering the lake to eliminate contaminant source

Operational Criteria:

- One-year operation (or until the final remedy for OU 4 has been decided)
- Operation through closure, or until a secondary treatment option, such as phytoremediation, can be established
- Surface water, sediment, ambient air, and groundwater sampling and analysis
- Ecological monitoring
- System operation, maintenance, and monitoring

Description of Major Components:

Hydraulic Control

- Control of the contaminants entering the lake will be achieved during the IRA through use of a groundwater treatment technology. The evaluation of these technologies is included elsewhere in this report.

Air Diffusion/Sparging

- An air diffuser system will be used to removed VOCs from surface water. The most effective application would be to install in concert with a groundwater technology.

- The system will be installed by resting perforated diffuser pipes above the sediment mat, air would be injected through the pipe to strip VOCs from the surface water above the mat.

- Because of the limited depth of surface water above the organic sediment mat and possible short circuiting of air to water contact due thick aquatic growth, the diffuser pipes will require close spacing to get effective removal efficiencies of VOCs in the surface water.

- An onsite pilot test should be conducted to evaluate the effectiveness of the diffuser system prior to full-scale implementation.

Groundwater, Surface Water, Sediment and Eco-System Monitoring

- Monitoring for the groundwater system will occur on a biweekly basis for the first month, then monthly until the end of the anticipated operational period.

- Monitoring schedules for the air diffusion/sparging system would run concurrent with the groundwater treatment monitoring.

Evaluation:

Evaluation of technologies to provide control of contaminants entering the lake through groundwater are provided elsewhere in this report. The following discussion will focus only on air diffusion/sparging of the surface water above the organic sediment mat in the lake.

Overall Protection of Human Health and the Environment

- Implementation of this technology may reduce the mass of contaminants in the surface water above the sediment mat.
- The use of this technology may potentially cause risks not associated with other interim remedial technologies. A preliminary assessment of these potential risks from VOCs in the air from the air sparging technology was performed. Preliminary calculations were made to determine an acceptable level of VOCs in the ambient air that would not cause an excess cancer risk greater than 10^{-6}. These calculations indicate that it is unlikely that the air sparging treatment technology would cause an unacceptable risk to residents of the condominiums adjacent to the site. (These calculations were presented in the pages following the evaluation section for air sparging.)
- Addition of oxygen and turbulence created by the aeration could possibly pose negative ecological effects.

Compliance with ARARs

- This alternative may comply with chemical-specific ARARs (Florida surface water standards) in the short term.
- Compliance with location-specific ARARs (such as those governing the wetlands or the lake ecosystem) may not be possible; however, it is currently being evaluated.
- A permit would be required if this technology were installed in the wetland area. The permit, a minimum activity permit, would be required, and is relatively easy to obtain.
- A permit would most likely not be necessary for the air stripper because the stripper would be considered a small source in operation for less than 5 years.

Long-Term Effectiveness and Permanence

- Implementation of this alternative would not be effective in the long term unless combined with treatment of VOCs in groundwater and sediment.
- Implementation of source controls may eliminate need for technology.

Reduction of Toxicity, Mobility, and Volume of Contaminants Through Treatment

- This alternative may reduce toxicity, mobility, and volume of VOCs in surface water above the sediment mat.

- Unclear how surface water depth limitations will affect the efficiency of the technology. With limited efficiency, the technology implementation may cause increases of vinyl chloride concentrations.

- Effects on the ambient air quality as a risk will be evaluated.

Short-Term Effectiveness

- If air to water contact is sufficient, implementation of this technology should result in an immediate decrease of VOC concentrations in surface water above the sediment.

- Workers who may implement this technology may be exposed to unacceptable risks that have not yet been quantified.

Implementability

- Construction of diffuser pipes on top of the sediment mat along with connection to a header and an air compressor should be relatively easy to implement.

- All system components are readily available.

- Wetland concerns may inhibit implementability.

Cost

- Direct cost estimated to be $59,000.

- Site O&M and monitoring costs are estimated to be $70,000 per year. Much of this cost may be shared with any groundwater treatment option.

- Reporting costs are estimated at approximately $129,000.

Consistency with Final Remedy

- Consistency with final remedy is dependent on source control alternative chosen.

Regulatory/State Acceptance

- EPA and FDEP seem to have concerns with implementation of this technology at the OU.

Community Acceptance

- Community concerns regarding implementation of this technology is anticipated not to be favorable.

4.0 ALTERNATIVE IDENTIFICATION MATRIX

The OPT has requested that various alternatives be identified that include implementation of aforementioned technologies at different areas of the site.

Alternatives for implementing various groundwater technologies are identified on the first table.

Alternatives for implementing various surface water or sediment technologies are identified on the second table.

Because it is unclear at this time whether or not a groundwater and a surface water/sediment technology would be implemented simultaneously, these alternatives options are not identified. However, the OPT should evaluate the following two tables side by side and realize that any number of combinations of a groundwater technology with a surface water/sediment technology is possible.

Table 1
Alternative Identification Matrix -- Groundwater Technologies

Information for Evaluation of Interim Remedy
Operable Unit 4 Interim Remedial Action
Naval Training Center, Orlando

Alternative	Groundwater		
	Extraction/ Treatment	Air Sparging	In-Well Air Stripping
1	X (hot spot)		
2		X (lakeshore)	
3			X (lakeshore)
4	X (hot spot)	X (source)	
5	X (hot spot)		X (source)
6	X (hot spot)	X (lakeshore)	
7	X (hot spot)		X (lakeshore)
8	X (hot spot)	X (source)	X (lakeshore)
9	X (hot spot)	X (lakeshore)	X (source)
10	X (hot spot)	X (source) X (lakeshore)	
11	X (hot spot)		X (source) X (lakeshore)
12		X (source)	X (hot spot)
13		X (source)	X (lakeshore)
14		X (source)	X (lakeshore) X (hot spot)
15		X (lakeshore)	X (hot spot)
16		X (lakeshore)	X (source)
17		X (lakeshore)	X (source) X (hot spot)

1) hot spot = the area where the highest level of contamination was detected, or the area where the existing extraction well is located.
2) source area = the assumed source, or the vicinity of the surge tank
3) lakeshore = the area where shallow groundwater discharges to surface water
4) It is assumed that groundwater extraction and treatment would only be implemented in the hot spot.

Table 2
Alternative Identification Matrix -- Surface Water/Sediment Technologies

Information for Evaluation of Interim Remedy
Operable Unit 4 Interim Remedial Action
Naval Training Center, Orlando

Alternative	Surface Water/Sediment			
	Natural Attenuation	Enhanced Bioremediation	Phyto-Remediation	Air Diffusion/Sparging
1	X			
2		X		
3		X	X	
4		X		X
5			X	
6			X	X
7				X

APPENDIX D

INDUSTRIAL USER DISCHARGE PERMIT BETWEEN THE CITY OF ORLANDO AND NTC, ORLANDO

City of Orlando

ENVIRONMENTAL CONTROL SECTION
ENVIRONMENTAL SERVICES DEPARTMENT

5100 L.B. McLEOD ROAD
ORLANDO, FLORIDA 32811

TELEPHONE (407) 246-2664
FAX (407) 246-2886

July 25, 1995

Lt. Commander Catherine A. Ballinger
United States Navy
1350 Grace Hopper Avenue, Suite 010
Orlando, FL 32813

RE: INDUSTRIAL USER DISCHARGE PERMIT NO. C062OA

Dear Lt. Commander Ballinger:

This Industrial User Discharge Permit has been prepared on the basis of all available information obtained from correspondence and from the investigation of your industry by the City of Orlando Environmental Services Department personnel.

IT IS IMPORTANT THAT YOU READ THE ENTIRE CONTENTS OF THIS DOCUMENT

The Permit is valid for five (5) years as long as there is compliance with all Permit conditions. The Permit is also subject to renewal and change as stated in Chapter 30 of the City Code.

The Industrial User Permittee shall comply with the City Code of the City of Orlando, Chapter 30, or with the applicable and related state or federal regulations, which ever may be the most stringent. Specific industrial pretreatment conditions are listed under Sections B, C and D.

If you have any questions pertaining to the Permit conditions or the information set forth in this letter, please contact the City's Environmental Control Section at (407) 246-2664 or (407) 246-2213.

Very truly yours,

Thomas L. Lothrop

Thomas L. Lothrop, P.E.
Director, Environmental Services

Colan S. Benner

Colan S. Benner
Environmental Supervisor
Environmental Control Section

TLL/CSB/llr

Save - Conserve water and reduce wastewater

City of Orlando

ENVIRONMENTAL CONTROL SECTION
ENVIRONMENTAL SERVICES DEPARTMENT

5100 L.B. McLEOD ROAD
ORLANDO, FLORIDA 32811

TELEPHONE (407) 246-2
FAX (407) 246-2886

July 25, 1995

Lt. Commander Catherine A. Ballinger
United States Navy
1350 Grace Hopper Avenue, Suite 010
Orlando, FL 32813

RE: INDUSTRIAL USER DISCHARGE PERMIT

Dear Lt. Commander Ballinger:

Attached is your Industrial User Discharge Permit for your records. Please read over the contents carefully. Any comments previously submitted have been reviewed and considered by the City's Environmental Control Section and Legal Affairs Office. Please submit any further comments or questions you may have within ten (10) working days of the delivery of this Permit.

Very truly yours,

Colan S. Benner

Colan S. Benner
Environmental Supervisor

SB/llr

Attachment

c: Mark Zill
Greg Mudd
File

INDUSTRIAL USER DISCHARGE PERMIT

SIGNATURE PAGE

Company Name: UNITED STATES NAVY

Company Address: 1350 Grace Hopper Avenue, Suite 010
Orlando, FL 32813

Consultant Name: Greg Mudd
ABB Environmental Services, Inc.

Consultant Address: 1080 Woodcock Road, Suite 100
Orlando, FL 32803

Permit No.: CO62QA

Facility Name: United States Navy (Area C)

Lt. Commander Catherine A. Ballinger
Name of Representative (typed)

has read and understands this document.

Effective Date: 08/01/95

Expiration Date: 08/01/00

____
Signature of Representative

Permittee:

United States Navy
(Area C)

INDUSTRIAL USER DISCHARGE PERMIT
Number: C062QA
Category: Groundwater Discharge
Expiration Date: 08/01/00

Pursuant to federal, state, and local regulations, the United States Navy (Area C) (Industrial User) is hereby authorized to discharge industrial sewage into the City of Orlando sewerage system, subject to the conditions set forth in the Permit.

This Permit may be modified by the City of Orlando, or the state, or federal government, or the agencies thereof.

Failure on the part of the Industrial User to fulfill any of the Permit conditions shall be sufficient cause for immediate revocation of this Permit and/or other enforcement action, such as fines, administrative orders and/or suspension of sewer service. This Permit is further subject to termination in accordance with the terms and provisions of the City Code.

ANY ASSIGNMENT OR TRANSFER OF THIS PERMIT SHALL AUTOMATICALLY MAKE IT NULL, VOID, AND OF NO FURTHER EFFECT.

A. PERMIT CONDITIONS

1. The Industrial User shall, except as otherwise provided herein, comply with the City Code of the City of Orlando, Chapter 30, or with the applicable and related state or federal regulations, whichever may be the most stringent.

2. The Industrial User shall allow City of Orlando personnel exhibiting proper credentials access to its premises for the purpose of inspection, sampling verification and/or copying of records which are maintained as a result of this Permit or any requirements by state or federal regulations or all of these things. Also, all necessary records required by this Permit shall be retained by the User for a minimum of three (3) years.

Permittee:

United States Navy
(Area C)

INDUSTRIAL USER DISCHARGE PERMIT
Number C062QA
Category:Groundwater Discharge
Expiration Date: 08/01/00

B. **GENERAL LIMITATIONS ON WASTEWATER FLOWS AND CHARACTERISTICS**

1. The following limitations and conditions apply to the Industrial User's discharge, until such time as this Section may be modified or revoked.

2. Discharge to the City's sanitary sewerage system shall be limited as follows:
General: Water or wastes that the municipality has identified as likely, either singly or by interaction with other substances, to:

   a) harm either the sewerage system or the wastewater treatment process; or
   b) be otherwise incompatible with the treatment process; or
   c) cause a violation of local, federal, or state discharge permits issued to the City; or
   d) adversely affect receiving waters; or
   e) endanger life, limb, or public property; or
   f) constitute a nuisance; or
   g) create a fire or explosion hazard in the Publicly Owned Treatment Works (POTW) or its collection system; or
   h) cause corrosive structural damage to the POTW or its collection system; or
   i) cause obstruction to the flow in the POTW resulting in interference; or
   j) cause any abnormal oxygen demand (BOD, etc.) that will result in interference at the POTW; or
   k) create interference with the POTW biological processes or any other process due to excessive heat in such quantities that the temperature at the POTW exceeds 40 degrees Celsius (104 degrees Fahrenheit)

   shall not be discharged or caused to be discharged into the City's sanitary sewerage system.

   Slug (as defined by the City Code) shall not be discharged into the City's sanitary sewerage system.

   Solids or Viscous Substances including but not limited to sand, mud, glass, wood, plastic, rubber, latex, and lime slurries, in quantities or of such size capable of causing obstruction to sewerage flows, or to otherwise interfere with the operation or maintenance of the system, shall not be discharged into the City's sanitary sewerage system.

Permittee:

United States Navy
(Area C)

INDUSTRIAL USER DISCHARGE PERMIT
Number: C062QA
Category: Groundwater Discharge
Expiration Date: 08/01/00

3. The wastewater constituents listed below shall at no time be discharged in concentrations which exceed the limitations given:

Constituent (to be limited)	Maximum Concentrations, mg/l
Antimony	1.0
Arsenic	0.25
Barium	10.0
Beryllium	0.25
Biological Oxygen Demand (BOD)	300.0
Boron	1.0
Cadmium	0.26
Chromium (Total)	1.0
Cobalt	0.3
Copper	2.0
Cyanide	0.5
Grease	100.0
Lead	0.4
Lower Explosion Limit(LEL)	less than 5% (of LEL on the meter)
Lithium	0.03
Manganese	1.5
Mercury	0.005
Nickel	0.7
pH*	not less than 5.5 or greater than 9.5
Selenium	0.5
Silver	0.24
Sodium	300.0
Tin	5.0
Zinc	1.0
Total Metals	10.0
Total Phenols	0.5
Total Suspended Solids (TSS)	300.0
Total Toxic Organics (TTO)	2.13

* (pH excursions of 15 minutes or longer are considered pH violations)

Permittee:

United States Navy
(Area C)

INDUSTRIAL USER DISCHARGE PERMIT
Number: C062QA
Category: Groundwater Discharge
Expiration Date: 08/01/00

Parameter	Sample Type	Monitoring Frequency	Reporting Frequency
Antimony			
Arsenic			
Barium			
Beryllium			
BOD			
Boron			
Cadmium			
Chromium (Total)			
Cobalt			
Copper			
Cyanide			
Grease			
Lead			
LEL			
Lithium			
Manganese			
Mercury			
Nickel			
pH			
Selenium			
Silver			
Sodium			
Tin			
Zinc			
Total Metals			
Total Phenols			
TSS			
TTO			

A state-certified laboratory shall be used for analysis (except pH). Analysis may be performed in-house provided that the permittee petitions the City for approval of in-house analysis and that EPA-approved laboratory methodologies are used for analysis (see Title 40 CFR, Part 136). NOTE: If analyses are performed in-house, the City's laboratory result shall prevail for any split samples.

Reports on wastewater analysis and the amount of hazardous waste produced shall be submitted to the City of Orlando's Environmental Control Section as follows:

Permittee:

United States Navy
(Area C)

INDUSTRIAL USER DISCHARGE PERMIT
Number: C062QA
Category: Groundwater Discharge
Expiration Date: 08/01/00

G. UNCONTAMINATED COOLING WATER

Uncontaminated cooling water utilized by the Industrial User shall be permitted to be discharged into the City's sanitary sewerage system provided that:

1. Only metered City water shall be utilized by the Industrial User in its cooling processes (NOTE: Water from any other source may not be discharged into the City's system.);

2. Cooling water shall be directed through and treated by the Industrial User's wastewater treatment unit prior to discharge into the City's sanitary sewerage system; and

3. The total volume of cooling water discharged into the City's sanitary sewerage system shall not exceed three hundred (300) gallons per month.

H. UNCONTAMINATED INDUSTRIAL PROCESS WATER

Uncontaminated industrial process water utilized by the Industrial User shall be permitted to be discharged into the City's sanitary sewerage system provided that:

1. The source of the uncontaminated industrial process water is the City's metered water supply system; and

2. The uncontaminated industrial process water shall be discharged either in the Industrial User's sanitary-only sewer or at a point where it would not interfere with the determination of pretreatment compliance.

I. FEDERAL REGULATIONS

For applicable federal regulations, see the Code of Federal Regulations, Title 40, Part 403. Should you require a copy, please contact City of Orlando, Environmental Control Section, 5100 L. B. McLeod Road, Orlando, Florida 32811, (407) 246-2664.

Permittee:

United States Navy
(Area C)

INDUSTRIAL USER DISCHARGE PERMIT
Number: C062QA
Category: Groundwater Discharge
Expiration Date: 08/01/00

5. A signed monthly report must be submitted to the City of Orlando's Environmental Control Section each month (see attached sample format)

6. A signed Statement of Certification (see attached) must accompany all monthly reports.

STATEMENT OF CERTIFICATION

(to accompany each Self-Monitoring Report)

Date of Self-Monitoring Report: ______________________________

Company Name: ______________________________

____

Company Address: ______________________________

____

____

Company Tel. #: ______________________________

Company FAX #: ______________________________
(if applicable)

I certify under penalty of law that this document and all attachments were prepared under my direction or supervision in accordance with a system designed to assure that qualified personnel properly gather and evaluate the information submitted. Based on my inquiry of the person or persons who manage the system, or those persons directly responsible for gathering the information, the information submitted is, to the best of my knowledge and belief, true, accurate, and complete. I am aware that there are significant penalties for submitting false information, including the possibility of fine and imprisonment for known violations. I also understand that applicable civil and criminal penalties may apply for any violations of pretreatment standards, requirements and/or compliance schedules.

Name & Title of Representative: ______________________________
(Type or Print)

Signature of Representative: ______________________________

Date of Signature: ______________________________

SAMPLE

Monthly Groundwater Discharge Report

The following information must be submitted each month:

1. Company name, address, and telephone number
2. Date of discharge and drum identifier number
3. Total number of drums and/or gallons discharged
4. Discharge point
5. Name of person approving discharge
6. Signature of authorized company representative

NOTE: A copy of each report must be retained by your company for a minimum of three (3) years.

A report must be submitted each month, whether or not any discharges were made.

<u>TOTAL TOXIC ORGANICS EXCLUSION</u>

In lieu of monitoring for Total Toxic Organics (TTOs), the Industrial User may submit a Toxic Organic Management Plan (TOMP) that specifies, to the satisfaction of the Director of the City of Orlando's Environmental Services Department, the toxic organic compounds used, the method of disposal used other than the City's sanitary sewer system and procedures for assuring that toxic organics do not spill or leak into the wastestream.

If monitoring is requested by the Department of Environmental Services to establish compliance with TTO standards, the Industrial User need analyze for only those pollutants which would reasonably be expected to be present or are expressly requested by the Environmental Services Director.

ALL self-monitoring reports shall be appended with the following **<u>signed</u>** certification:

"Based on my inspection of compliance with the pretreatment standard for Total Toxic Organics (TTOs), I certify that no discharge of toxic organics into the wastewaters has occurred since the last self-monitoring report was filed. I further certify that this facility is abiding by its toxic organic management plan as approved by the Director of the City's Environmental Services Department."

Ref: CFR 413.03 a)-c)

APPENDIX E

GROUNDWATER TREATMENT ESTIMATED VAPOR EMISSIONS

OU4-INTERIM REMEDIAL ACTION
GROUNDWATER TREATMENT
ESTIMATED VAPOR EMISSIONS

Maximum contaminant concentration estimates are based on the Focused Field Investigation groundwater sampling results and groundwater sampling results from the August 1996 pumping test:

1)	Trichloroethylene	: 2700 μg/L or 2.66 mg/L
2)	Tetrachloroethylene	: 500 μg/L or 0.17 mg/L
3)	cis- 1,2 Dichloroethylene	: 700 μg/L or 0.61 mg/L

In-Situ Groundwater Treatment System (UVB-400)

Water Flow Rate:	8 m^3/hr
Number of Treatment System Wells:	To be decided by vendor, calculations are for one treatment well.
Air/Water Ratio:	50:1
Removal Efficiency:	Assume 100% Actual 90% - 95%

Formula for anticipated maximum vapor (off gases) emissions:

(Water Flow) x (Contaminant Conc.) x (removal efficiency) = off gas emissions

1) Trichloroethylene

(8 m^3/hr) x (24 hr/day) x (2.70 mg/L) x (.001 g/mg) x

(.0022 lb/g) x (1000 L/m^3) x (1.00) = <u>1.14 lb/day/per well or</u>
<u>416 lb/year/per well</u>

2) Tetrachloroethylene

(8 m^3/hr) x (24 hr/day) x (0.50 mg/L) x (.001 g/mg) x

(.0022 lb/g) x (1000 L/m^3) x (1.00) = <u>0.21 lb/day/per well or</u>
<u>77 lb/year/per well</u>

3) cis- 1,2 Dichloroethylene

$$(8\ m^3/hr) \times (24\ hr/day) \times (0.70\ mg/L) \times (.001\ g/mg) \times$$

$$(.0022\ lb/g) \times (1000\ L/m^3) \times (1.00) = \underline{0.30\ lb/day/per\ well\ or}$$
$$\underline{108\ lb/year/per\ well}$$

Total vapor emissions per day and year, for each well are therefore approximately **1.65** and **601 lb** total volatile organic compounds (VOCs), respectively. This estimate is based on the following assumptions: the groundwater treatment system is 100% efficient in stripping the VOCs from the groundwater; and that the VOC concentrations will remain in the approximate range all year long.

In reality, VOC concentrations in the treated water are expected to decrease. At system start-up, VOCs will likely be emitted at the rates calculated above. However, VOC concentrations within the treatment cell around each well should be quickly reduced. When the treatment cells are fully established, the total VOC emissions from the treatment system should approximate the current rate of VOC emissions to Lake Druid, or 25 lb/year.

These calculations assume the treatment system will be intercepting the plume in the vicinity of the existing recovery well (RW-1). Air emissions will increase if an additional system is installed in the source area.

COMP. BY:	DATE:	CHK. BY:	DATE:	CHK. BY:	DATE:
		H. T	4/22/97		

Florida Department of

Environmental Protection

Memorandum Jim Crane

DARM-OGG-03
Revised

BUREAU OF WASTE CLEANUP

MAY 2 3 1996

TECHNICAL REVIEW SECTION

TO: Bureau of Waste Cleanup
Bureau of Air Regulation
District Waste Program Administrators
District Air Program Administrators
District Waste Cleanup Supervisors
District Tanks Supervisors
Local Program Tank Supervisors
Local Air Program Administrators

FROM: John M. Ruddell, Director JMR
Division of Waste Management

Howard L. Rhodes, Director HLR
Division of Air Resources Management

DATE: May 17, 1996

SUBJECT: Revised Guidance on Air Emissions from Petroleum Cleanup Sites

This guidance replaces the February 27, 1996 Guidance, DARM-OGG-03.

This memorandum provides guidance for evaluation of air emissions that will result from the cleanup of petroleum contaminated sites. This guidance replaces all previous guidance memoranda related to air emissions evaluation and control for groundwater treatment air strippers and vacuum extraction systems at petroleum contaminated sites.

The Bureau of Waste Cleanup is responsible for the cleanup of many petroleum contaminated sites throughout the state. The cleanup systems on these sites will not be identical but will have similarities as far as considerations for air emissions control and evaluation. It is the intent to avoid duplicate efforts by Air and Waste Cleanup program staff in the evaluation of these cleanup systems. Therefore, the staff of the Bureau of Waste Cleanup and contracted local program offices will evaluate air emissions sources from existing and proposed petroleum contaminated site cleanup systems in accordance with the provisions of this memorandum. Provided that systems are designed and operated in accordance with the terms of this memorandum, the Remedial Action Plan Approval Order will serve as evidence that air emissions concerns have been adequately addressed. No separate air permit will be required for the operation of the cleanup system, as long as the procedures outlined in this memo for air emissions evaluation, treatment, and monitoring are followed unless the soil remediation unit is located at a facility that is a Title V source. If the unit is at a Title V source, it should be reported as an emissions unit and should be included in the Title V permit pursuant to Rules 62-213.420 and 440, F.A.C.

It is assumed that air emissions sources associated with petroleum cleanup sites will be temporary in nature, that is, will be operated less than 5 years. The Remedial Action Plan must include an estimate of the site cleanup duration. If the cleanup is projected to last greater than 5 years, the District Air Program Administrator must be contacted to obtain an air permit or an exemption under the provisions of Chapter 62-4, F.A.C.

The maximum air emissions from a cleanup site may not exceed 15 pounds per day of volatile organic compounds (VOCs), as determined by EPA Method 18 or other methods with prior approval of the Division of Air Resources Management and the Division of Waste Management. When several technologies are used together on a cleanup site, the air emissions from the multiple sources must be considered together in determining the combined air impacts from the site cleanup activities and the need for air emissions control. The emissions may be determined by direct measurement of the air stream for vapor extraction systems or on the basis of mass transfer of hydrocarbons from water phase to air phase in an air stripper system.

Recent years have seen the development of several new approaches to site cleanup. These processes each have different air emissions potentials and concerns due to the nature of the site cleanup process. A brief description of each process and the air emissions evaluation and control procedures for the process are described individually below.

Vapor extraction

Soil vapor extraction (SVE) or vacuum extraction is an accepted and proven technique for removing volatile organic compounds from the unsaturated zone of soils. The process typically involves several screened vacuum extraction lines, installed either vertically or horizontally, that are manifolded together to a single mechanical equipment system. In this technology, a vacuum is applied to the soil matrix to create a negative pressure gradient that causes movement of vapors toward the extraction wells. Vacuum extraction systems, as distinguished from bioventing systems, typically have relatively high vacuums and air flow rates. These systems primarily remediate soil by causing the volatilization of hydrocarbons adsorbed to soil through the induced vacuum and air flow through the soil. These systems are more effective on lighter petroleum products that are composed predominantly of compounds with higher vapor pressures. The remediation typically removes the greatest mass of VOCs and results in highest concentrations of recovered vapors in the first few days or weeks of operation.

The equipment system typically consists of a blower to create a vacuum, a knock out tank to reduce moisture, an air emissions treatment device, and valves, pressure gauges and air flow meters. Several variations of air emissions devices may be used, including activated carbon, catalytic oxidation, thermal oxidation or a biofilter. The type of air emissions treatment equipment selected will depend on anticipated air flow rates and VOC concentrations.

Vacuum extraction systems will generally be proposed where sites have soils excessively contaminated with VOCs. At such sites, due to the relatively high rates of hydrocarbon recovery in the early stages of vacuum extraction system operation, air emissions control at startup is generally mandatory. The Bureau of Waste Cleanup will consider site specific considerations if there are no excessively contaminated soils present or it is determined the petroleum hydrocarbons present will not be readily volatilized. The air emissions treatment device shall continue operation for the first 30 days of the vacuum extraction system operation. At the end of 30 days, air samples of recovered vapors shall be collected from the recovered vapor air stream without the air emissions treatment device. The air emissions, after controls, must be less than 15 pounds per day. Samples shall be collected in a tedlar bag and analyzed by EPA Method 18 or other methods, with prior approval of the Division of Air Resources Management and the Division of Waste Management, to determine total VOC concentrations. The VOC analytical result shall be used to calculate the daily pounds of VOCs recovered based on the measured air flow rate. If the recovered VOCs (including any other emission sources from the site remediation) are less than 15 pounds per day without controls, air emissions treatment may be discontinued. If the recovered VOCs are 15 pounds per day or greater, the air emissions control shall continue until subsequent samples demonstrate the VOC air emissions are less than 15 pounds per day.

Bioventing

Bioventing is an in-situ remediation technology that uses indigenous microorganisms to biodegrade organic constituents adsorbed to soils in the vadose zone. The activity of the indigenous bacteria is enhanced by inducing flow of air (to supply oxygen for microorganism metabolism) through the unsaturated zone. The system design is similar to a vacuum extraction system in that there will be extraction (or injection) wells manifolded to an equipment system which includes a blower. The system design is different from soil vacuum extraction, however, in that air flow rates are generally much lower and air may be either injected to the unsaturated zone or withdrawn by applying a vacuum. Bioventing is most often used at sites with mid-weight petroleum products such as diesel fuels and jet fuel because lighter fuels such as gasoline tend to volatilize readily and can be removed more rapidly with soil vapor extraction.

Because this process relies on degradation of petroleum hydrocarbons by microorganisms rather than volatilization, air emissions control is not required. To qualify as bioventing and operation without air emissions control, the Remedial Action Plan must demonstrate that the remediation mechanism will be primarily biodegradation and must show that the uncontrolled air emissions are less than 15 pounds per day. This will generally necessitate the performance of a pilot study and subsequent system design (air flow rates) based on respiration rates established from the pilot study. Additionally, if the site is gasoline contaminated, startup air samples shall be obtained to verify no significant recovery of vapors by the system operation.

In-situ Sparging

In-situ air sparging is an in-situ remedial technology that reduces concentrations of volatile constituents in petroleum products that are adsorbed to soils in the saturated zone and dissolved in the groundwater. This technology involves the injection of contaminant-free air into the subsurface saturated zone, enabling a phase transfer of hydrocarbons from dissolved state to a vapor phase. The air is then vented through the unsaturated zone. Soil vapor extraction is used in conjunction with in-situ sparging to recover the volatilized hydrocarbons. Air sparging is generally more applicable to the lighter petroleum constituents and therefore most effective on gasoline contaminated sites. There is evidence to show that in-situ bioremediation may also be induced during in-situ sparging, however, for the purpose of this discussion it is assumed that the remediation mechanism is predominantly volatilization of petroleum hydrocarbons. A separate section below describes "biosparging" as a distinct process with different air emissions control considerations.

In-situ sparging systems are required to be operated in conjunction with a soil vapor extraction system and the soil vapor extraction system is required to have an air emissions treatment system at system startup due to the relatively high rates of hydrocarbon recovery in the early stages of in-situ sparging and vacuum extraction system operation. The air emissions treatment device shall continue operation for the first 30 days of the in-situ sparging and vacuum extraction system operation. At the end of 30 days, air samples of recovered vapors shall be collected from the recovered vapor air stream without the air emissions treatment device. The air emissions, after controls, must be less than 15 pounds per day. Samples shall be collected in a tedlar bag and analyzed by EPA Method 18 or other methods with prior approval of the Division of Air Resources Management and the Division of Waste

Management to determine total VOC concentrations. The VOC analytical result shall be used to calculate the daily pounds of VOCs recovered based on the measured air flow rate. If the recovered VOCs (including any other emissions sources from the site remediation) are less than 15 pounds per day without controls, air emissions treatment may be discontinued. If the recovered VOCs are 15 pounds per day or greater, the air emissions control shall continue until subsequent air samples demonstrate the recovered vapors are less than 15 pounds per day uncontrolled.

Biosparging

Biosparging is an in-situ remediation technology that uses indigenous microorganisms to biodegrade organic constituents in the saturated zone. In biosparging, air and nutrients (if needed) are injected into the saturated zone to increase the biological activity of the indigenous microorganisms. The biosparging process is similar to in-situ air sparging. However, while in-situ air sparging removes constituents primarily through volatilization, biosparging promotes biodegradation of constituents rather than volatilization. Biosparging systems will typically have lower air flow rates designed on the basis of providing adequate oxygen supply to optimize biological activity without causing significant volatilization of hydrocarbons.

A biosparging system may be operated along with a bioventing system, a soil vapor extraction system, or with no soil venting system at all. This will depend to a large degree on the extent and nature of contamination of the unsaturated zone. If the extent of contamination to the unsaturated zone is not great enough to warrant any soil remediation system, no soil venting system is required to be operated with biosparging. If the extent of soil contamination warrants a soil remediation system, either vapor extraction or bioventing may be operated in conjunction with biosparging. If a vapor extraction system is proposed, the air emissions control and evaluation procedures described above under "soil vapor extraction" are applicable. If a bioventing system is proposed and the RAP demonstrates that both the biosparging system and bioventing systems will be predominantly bioremediation mechanisms and are designed on the basis of respiration rates of microorganisms, no air emissions control is required if it can be shown that the uncontrolled air emissions are less than 15 pounds per day.

Air Stripping of Recovered Groundwater

Air stripping in the context of this memo refers to any process in which dissolved hydrocarbons in recovered groundwater are transferred from dissolved phase to air phase through mechanical processes. The most common types are packed tower air strippers, aeration tanks, or tray-type aerators. Typically the recovery rate of hydrocarbons dissolved in groundwater results in a relatively low air emissions impact compared with the vacuum extraction and in-situ sparging technologies discussed above. The Department's experience is that air stripping of recovered groundwater generally results in relatively low air emissions that do not require treatment. The evaluation is to be based on the concentration of total volatile organic aromatics (VOAs) in recovered groundwater as determined by EPA Method 602. It shall be assumed that the results of the 602 analysis (BETX) represents 10 percent of the total VOCs. Considering the relatively low effluent standards for most treated groundwater disposal options, it should be assumed that all VOCs measured in groundwater are converted to the air phase. The VOC analytical result shall be used to calculate the daily pounds of VOCs recovered based on the design groundwater recovery rate. If the recovered VOCs (including any other emissions sources from the site remediation) are less than 15 pounds per day, air emissions treatment is not necessary. If the recovered VOCs are 15 pounds per day or greater, air emissions treatment shall be required.

If both soil vapor extraction and air stripping of recovered groundwater are operated on a site, it is generally appropriate to use the air emissions control device on the soil vapor extraction system first. Treating the vacuum extraction air emissions alone will generally reduce total air emissions to less than 15 pounds per day of VOCs. The air emission control shall continue until subsequent samples demonstrate the vapor emissions are less than 15 pounds per day.

Nuisance considerations

Notwithstanding the evaluation process described above, the RAP shall consider the location of the air emissions sources relative to receptors in the vicinity which could result in odor nuisance, or health concerns due to the direct proximity to the emissions source. If necessary, the RAP shall include recommendations for equipment location, additional exhaust stack height or air emissions treatment to address such concerns.

Alternate Air Emissions Evaluation Methods

The pounds/day of VOCs method to determine the need for air emissions treatment is the preferred method. If this evaluation results in a determination that air emissions control equipment is necessary, a supplemental evaluation of ambient air impacts based on plume dispersion modeling may be performed for verification prior to a final decision to provide an air emissions control device. The procedures in Attachment A shall be followed to make this demonstration.

Listed below are the ambient reference concentrations (ARCs) developed by the Division of Air Resources Management (DARM) for some of the petroleum constituents. This table includes both a column for 24 hour ARCs and a column for annual ARCs.

The 24 hour ARC is derived from occupational exposure levels such as the PELs set by OSHA or Threshold Limit Values that are based on the American Conference of Governmental Industrial Hygienists (ACGIH). The DARM has derived an equation to determine the 24 hour ARC values for different petroleum constituents. The equation is: TLV/420 = 24 hr ARC. Please note that these values are only utilized for short term exposures. Any type of air emissions which occur over a longer period of time should be evaluated based on the estimated annual average ambient concentration and compared against the reference values in EPA's Integrated Risk Information System (IRIS) database. Since five years will be the determining factor on whether an air permit is required, the Department will utilize the five year period as a cutoff between the use of a 24 hour ARC or an annual ARC. Any remedial action plan which estimates air emissions over a five year period should use the annual ARC values.

The TSCREEN Model will provide a 1 hour concentration as the default output. This model can also convert to a 24 hour concentration. Therefore, when a Remedial Action Plan proposes an air emission of less than five years, the model output for a 24 hour emission can be compared directly to the table shown below. However, if the Remedial Action Plan estimates air emissions over five years, the TSCREEN model does not convert from a 1 hour average to an annual average. Therefore one must use a conversion factor from a 1 hour average to an annual average and hand calculate these numbers. This conversion factor is 0.08.

This table does not include a 24 hour ARC for MTBE or an annual ARC for naphthalene. One should substitute the value provided and compare this value to that calculated from the TSCREEN model. For example, the 24 hour ARC for MTBE should be 3000 ug/m3 and the annual ARC for naphthalene should be 119 ug/m3.

With the exception of naphthalene, the polynuclear aromatic hydrocarbons (PAHs) were not included on this table because: (1) There are only two ARC values available; (2) All of the PAHs are semi-volatile organics with a relatively low Henry's Constant. Therefore, the PAHs emitted to the air should be of a low magnitude; (3) The concentrations of PAHs discovered in the soil or the groundwater are typically less than 1 ppm (1000 ppb).

CHEMICALS	24hr ARC ug/m3	annual ARC ug/m3
benzene	7	0.12
1,2-Dicholroethane	95	0.038
1,2-Dibromoethane (EDB)	71	0.0045
MTBE	—	3000
ethylbenzene	1033	1000
naphthalene	119	—
toluene	448	400
xylene	1033	80

JMR/HLR/h

Attachment

ATTACHMENT "A"

MODELING OF AIR EMISSIONS

The Department recommends the use of TSCREEN when determining the appropriate stack height of an air emission and whether air emission controls can be removed from a source of air emissions

Purpose of TSCREEN

TSCREEN is an easy-to-use, interactive, menu-driven, point-source screen model. The purpose of TSCREEN is to quickly and easily screen a point source emission to determine the maximum downwind concentration and the location of this maximum concentration. TSCREEN applies to a continuous point source and includes in the model a built-in worst case meteorology. Worst case meteorology is that combination of wind speeds and stability classes that can physically occur and runs all these cases for the "X" direction. It also uses the standard Gaussian equation, the Briggs plume rise and can consider nearby buildings for downwash, and/or account for fencelines.

Averaging Times

The default averaging time in the TSCREEN model is 1 hour. The maximum concentration can be calculated for additional averaging times selected from the menu. These times include: 15 minutes, 30 minutes, 3 hours, 8 hours, and 24 hours. To associate the ambient reference concentrations (ARC) developed by the Division of Air Resources Management with the results from TSCREEN, one should use the 24 hour averaging time and compare this to the 24 hour ARC.

Model Input

1. Always use 293° K for the ambient air temperature. An estimate should be made of the expected stack exit gas temperature.

2. The flat terrain should be used for sites in Florida.

3. Always use the rural terrain, except if the site is in the center of a large metropolitan area.

4. If a building is within the distance of five times the largest dimension of the building (height, width or length), then the building should be included in the model.

5. If a receptor is within close proximity of the stack (e.g., intake to ventilation system), flagging of this receptor should be included.

6. The receptor height for people standing on the ground should be 0.0.

7. In most cases use a small value (1.0 meter) for the distance to the outside of the site property unless institutional control of site access is possible.

8. The TSCREEN model can only calculate from one source. If there is more than one source one should combine the concentrations and input this data for the more conservative stack (e.g., lower exit temperature, lower velocity, shorter stack), or use the Industrial Source Complex Model.

9. The program will calculate the 1 hour maximum concentration in ug/m3. Use the 24 hour averaging time and compare this result to the ambient reference concentrations provided below. If the results show that the emissions are below ARC at the area of greatest impact, then either the stack

height is appropriate or the air emission control may be discontinued after concurrence from the Department (or local program).

Model Output

The SCREEN model output begins with the times and date that the model was run. Next, there is the model name and version number. Following the model name is the run's title and the user input. Next, the output contains a summary of results showing the maximum concentration and the distance to the maximum. Next, there is a list of concentrations for TSCREEN's automated distances. Finally, there is a listing of the cavity concentrations. Note: cavity concentrations are only listed if the effects of building downwash are being considered. The 24 hour averaging time result is at the end of the model output.

How can TSCREEN be obtained?

TSCREEN can be obtained from the EPA's Support Center for Regulatory Air Models (SCRAM) Bulletin Board System (BBS). The telephone number for access by modem is 919/541-5742.

APPENDIX F
BACKUP FOR COST ESTIMATES

RECIRCULATION/IN SITU STRIPPING

January 10, 1997

Mr. Harlan Faircloth
ABB Environmental Services, Inc.
1080 Woodcock Road, Suite 100
Orlando, FL 32803

RE: Naval Training Center, Orlando
Revised Design and Cost Estimate

Dear Harlan:

FGS/SBP Technologies Inc. is pleased to provide this revised design and cost estimate for the referenced project. The primary change is the addition of another UVB-400 to form a treatment wall which can provide better coverage of the contaminant plume. The mounding issue has been resolved and Dr. Eric Klingel of IEG Technologies is in the process of collecting empirical data to verify the design. Dr. Klingel will present this data at the meeting on January 16th. Additionally, we have requested a correlation for calculating the mounding effect from the original modelers in Germany. This information will likely be available for the meeting. Dr. Klingel is very familiar with this design and will be able to address any issues or concerns at the meeting.

BACKGROUND DATA

The following data was used to design the UVB system:

1. Horizontal Hydraulic Conductivity (K_h) = 1.2×10^{-4} m/s
2. Vertical Hydraulic Conductivity (K_v) = 1.2×10^{-5} m/s
3. Depth to groundwater = 2 - 4 ft
4. Contaminant Plume is 45 ft thick
5. Contamination is chlorinated hydrocarbons in the 1000 ppb range
6. Porosity is approximately 25%
7. No free product is known to exist
8. Hydraulic gradient = .012

DESIGN

The UVB design program inputs and outputs are presented in Attachment 1. The theoretical maximum distance (D) between the two wells to provide complete capture is 48.9 m (160 ft). A distance of 90% of D (44 m, 144 ft) was selected for design purposes. Figure 1 depicts the well locations relative to the contaminant plume. Figure 2 provides dimensions of the circulation cells. Figure 3 is a cross section of the circulation cells which includes outlines of the 100 and 1000 ppb VOC contours. Please keep in mind that the plume contours are from a location downgradient of the UVB wells and the circulation cell cross sections are for a theoretical distance 5H (H = 45 ft) upgradient of the UVB wells. The figure is provided only for a rough comparison of the two.

The UVB stripping reactors will operate at an air to water ratio of 50:1 providing 90 - 95% removal of chlorinated compounds as the plume passes through the treatment wall.

Figure 4 is a plot of circulation time versus % of stagnation point (S). Circulation time is defined as the time it takes a particle of water to move from the upper screen through the stagnation point or some % of the stagnation point to the lower screen.

COST ESTIMATE

The following are costs for the revised design:

1.	Pilot Study	$ 12,800
2.	Design	$ 9,800
3.	Two complete UVB 400 Systems	$127,360
4.	Miscellaneous Equipment	$ 2,000
5.	Project Management/Health & Safety	$ 6,200
6.	Scheduling, Mobilization/Demobilization	$ 2,800
7.	UVB Well Installation/Development	$ 26,800
8.	System Installation	$ 18,985
	TOTAL	**$206,745**

PROJECT	COMP. BY	JOB NO.
Recirculation / In Situ Stripping Cost Est.	H.F.	
	CHK. BY	DATE

Monitoring Wells (Head responce, Influent/Effluent)

$30/ft (All inclusive)

6 wells - 3 shallow / 3 deep

3 shallow @ 20 ft $30/ft = 1,800.00

3 deep @ 60 ft $30/ft = 5,400.00

→ $7,200.00

Drilling IDW @ $100/drum

Monitoring Wells — shallow 3 drums per well 900

Deep 5 drums per well $1,500

7.48 gallons / 1 ft³

(2) 16"Ø recirc wells w/ 24"Ø annulus $2400

$\text{Area} = \left(\frac{1}{2}\,{}^{24}/_{12}\right)^2 \pi \approx 3.14\ ft^2$

$3.14\ ft^2 \times 50\ ft \approx 157\ ft^3$

Bulking factor of 30% ⇒ $157\ ft^3 \times 1.30 = 204\ ft$

$= \frac{7.48\ gal}{1\ ft^3} \times 204 = 1527\ gal$

$1527 / 55_g \approx 28$ drums

2 wells ⇒ 28 × 2 = 56

= $5600

5600 + 2400 = $8000

Trenching & Piping

Assume 600 LF

- Between Wells → to power supply @ $3.00/LF

= $1,800

FORM 00.01 REV. 5/93

ABB Environmental Services, Inc.

PROJECT Recirc/Insitu Stripping Cost Est.	COMP. BY H.F	JOB NO.
	CHK. BY	DATE

Startup (Labor) ≈ 2 to 3 weeks

Personnel	Base (hour)	Rate	Mult.	Total
Engineer (full)	120	20	2	4,800
Engineer (part)	40	20	2	1,600
Senior Eng	30	30	2.3	2,070
PM	10	40	2	800
				= 9270

Assume $500 in Analytical
200 in Misc. ≈ ⟹ $10,000

Construction Management 3 - 4 weeks (Labor)

Geologist	100	20	2	4,000
Engineer	150	20	2	6,000
Sen Eng	40	30	2.3	2,760
PM	16	40	2	1,280
				14,040

≈ $14,000

PROJECT Recirc / In-Situ Stripping Cost Est	COMP. BY H.F	JOB NO.
	CHK. BY	DATE

O & M

Power (5 hp, 208v 3 phase)

1 hp = .746 KW

5 hp × .746 KW = 3.73 KW

Assume \$0.07 / KW hr

Cost per Month = $3.73\ KW \times \frac{\$.07}{KW\text{-}Hr} \times \frac{24\ Hr}{1\ day} \times \frac{30\ days}{1\ month}$

= \$ 187.99 / Month

Assume \$200 per month per well

∴ 2 wells = \$400 per month

Equipment (Misc parts & Supplies) \$ 100.00 per month

Labor (per Month)

	No.	Hour/month	Rate	Mult	
Engineer/Tech	(2)	10	\$20/hr	2.0	= 800
Tech Lead	(1)	8	\$30/hr	2.3	= 552
PM	(1)	3	\$40	2.0	= 240
					\$ 1592

⇒ \$1600

PROJECT Recirculating / Insitu Stripping Cost Est	COMP. BY H.F.	JOB NO.
	CHK. BY	DATE

Site Monitoring

- Monthly SW/SD Sampling @ 4 Locations
  $55/sample 8 samples = $440/month

Bi Monthly Monitoring Well 12 wells $330/month

Influent/Effluent $55/sample (Bimonthly) 2 wells = $110/month

$880 → $900/Mo

LOE SW/SD (monthly)

	No	Hours	Rate	Mult	Total
Geologist/Eng/Tech	(2)	10	20	2	800
Tech Lead	1	4	30	2.3	276
PM	1	1	40	2	80
					1156

LOE Monitoring Well (Low flow Sampling)

Geo/Eng/Tech	2	30	20	2	2,400
TL	1	6	30	2.3	414
PM	1	2	40	2	160
					2974
					≈ 3000

Bi Monthly ∴ $1500

$25.00 Misc supplies

1500 + 1156 + 25 = 2681

≈ $2700

ABB Environmental Services, Inc.

EX SITU AIR STRIPPING

North East Environmental Products, Inc.
17 Technology Drive West Lebanon NH 03784
(603) 298-7061 Fax (603) 298-7063

September 18, 1996

Harlan Faircloth
ABB Environmental Services
1088 Woodcock Road, Suite 100
Orlando, FL 32803

RE: Proposal #996418
Site ID: ?

Dear Harlan,

In response to your request, North East Environmental Products is pleased to propose our three-tray **Model 2631** ShallowTray® low profile air stripper.

Expected performance for the **Model 2631** operating at the maximum of **50 gpm** and a minimum water temperature of 65°F follows (design operation range is 2-60 gpm, fresh air inlet of 600 cfm). Modeling for our five-tray Model 2351-P is also attached. I jotted the basic system price under the calculations for the fifth tray; options costs remain the same:

Contaminant	Untreated ppb	After 1st Tray ppb	After 2nd Tray ppb	After 3rd Tray ppb
c-1,2-Dichloroethylene	650	4	<1	<1
Tetrachloroethylene	200	8	<1	<1
Trichloroethylene	3,000	140	7	1

The power requirements as specified are 230 volt, 1 Ø, 3 wire and ground. This system's blower has been sized for the air stripper only. If additional air discharge pressure is required or if the site power requirements differ, please contact our office.

The price for the ShallowTray Model 2631, with optional components, is listed below:

Basic System Model 2631	
Sump tank & 1 tray, 304L stainless steel fabrication	
2 Additional tray(s), 304L stainless steel fabrication	
Forced Draft Blower, 3 tray, 5 hp, 600 cfm @ 14wc, 1 Ø, 230V, 60Hz, TEFC	
Inlet screen & damper, 304L SS mist eliminator, spray nozzle(s), sight tube, gaskets, SS latches, Sched 80 PVC piping, and tray cleanout & inspection ports w/caps.	
Basic System Price Model 2631	**$16,169**

Options		
Skid Mounting: Fabricated Frame with Control & Instrument Stanchion	1	$788
Air pressure gauge, pneumatic, in. H2O	1	$74
Discharge pump, 60 gpm, 50 tdh, 2 hp, 1 Ø, 230V, TEFC	1	$508
NEMA 3R Control Panel, w/Discharge Pump level controls, main disconnect switch, alarm interlocks, motor starter, & panel light, UL listed	1	$2,324
Panel Option: Intermittent operation circuitry	1	$336
Low Air pressure alarm/shutdown switch, pneumatic, EXP	1	$171
High water level alarm/shutdown float switch (N.C.)	1	$70
Discharge Pump level control float switch(es) (N.O.)	1	$70
Air flow meter, insertion pitot tube w/pressure gauge, pneumatic, in. H2O	1	$144
Line sampling ports, inlet and/or discharge	2	$53
Washer wand, duplex, with (2) high pressure spray nozzles, on rollers	1	$195
Options Subtotal		$4,731
Total Model 2631 System Price, Including Options, US$ Each:		**$20,901**

GRUNDFOS PUMPS PRICE LIST

EFFECTIVE DATE: JANUARY 2, 1997

REDI-FLO4 ENVIRONMENTAL PUMPS

						2-WIRE with GROUND Pump/Motor Assembly with Leads (Control box is not required)			3-WIRE with GROUND Pump/Motor Assembly with Leads and control box.		
TYPE	HP	PH	VOLTS	MOTOR LEAD LENGTH	MOTOR MFG.	PRODUCT NUMBER	APPROX. SHIPPING WT. (LBS.)	LIST PRICE ($)	PRODUCT NUMBER	APPROX. SHIPPING WT. (LBS.)	LIST PRICE ($)
25 GPM											
25E6	1	1	230	25'	G	05.00578	39	1,267.00	05.00588	43 1/2	1,345.00
				25'	F	05.00738	39	1,371.00	05.00748	43 1/2	1,467.00
25E6	1	1	230	50'	G	05.00598	40 1/2	1,359.00	05.00608	46	1,481.00
				50'	F	05.00758	40 1/2	1,516.00	05.00768	46	1,684.00
25E6	1	1	230	75'	G	05.00618	42	1,451.00	05.00628	48 1/2	1,617.00
				75'	F	05.00778	42	1,659.00	05.00788	48 1/2	1,899.00
25E6	1	1	230	100'	G	05.00638	44	1,541.00	05.00648	51	1,756.00
				100'	F	05.00798	44	1,805.00	05.00808	51	2,118.00
25E6	1	1	230	125'	G	05.00658	45 1/2	1,630.00	05.00668	53 1/2	1,891.00
25E6	1	1	230	150'	G	05.00678	47	1,721.00	05.00688	56	2,025.00
				150'	F	05.00818	47	2,092.00	05.00828	56	2,546.00
25E6	1	1	230	175'	G	05.00698	48 1/2	1,814.00	05.00708	58 1/2	2,160.00
25E6	1	1	230	200'	G	05.00718	50	1,905.00	05.00728	61	2,298.00
				200'	F	05.00838	50	2,383.00	05.00848	61	2,980.00
25E8	1 1/2	1	230	25'	G	05.00858	47	1,450.00	05.00868	46 1/2	1,532.00
				25'	F	05.01018	47	1,554.00	05.01028	52 1/2	1,651.00
25E8	1 1/2	1	230	50'	G	05.00878	48 1/2	1,542.00	05.00888	49	1,668.00
				50'	F	05.01038	48 1/2	1,699.00	05.01048	55	1,868.00
25E8	1 1/2	1	230	75'	G	05.00898	50	1,634.00	05.00908	51 1/2	1,804.00
				75'	F	05.01058	50	1,842.00	05.01068	57 1/2	2,083.00
25E8	1 1/2	1	230	100'	G	05.00918	52	1,724.00	05.00928	54	1,943.00
				100'	F	05.01078	52	1,988.00	05.01088	60	2,302.00
25E8	1 1/2	1	230	125'	G	05.00938	53 1/2	1,813.00	05.00948	56 1/2	2,078.00
25E8	1 1/2	1	230	150'	G	05.00958	55	1,904.00	05.00968	59	2,212.00
				150'	F	05.01098	55	2,275.00	05.01108	65	2,730.00
25E8	1 1/2	1	230	175'	G	05.00978	56 1/2	1,997.00	05.00988	61 1/2	2,347.00
25E8	1 1/2	1	230	200'	G	05.00998	58	2,088.00	05.01008	64	2,485.0
				200'	F	05.01118	58	2,566.00	05.01128	70	3,164.0

NOTES: Motor manufacturers: "G" - GRUNDFOS, "F" Franklin
Prices are effective only in the continental USA and are subject to change without notice.
GRUNDFOS Redi-Flo pumps are available in capacities to 32 GPM.

Assume $1600 each for submersible pump

PROJECT Pump & Treat Cost Est.	COMP. BY H.F.	JOB NO. 8545
	CHK. BY	DATE

Recovery Well Installation (from IRA Drilling Invoice)

Item	Quantity	Unit $	Total
Mobilization	1	1000	1000
Advance Cable Tool Drilling	65 LF	60	3900
Install Well (including stainless material, sand, bentonite and grout)	65 LF	70	4550
Water Truck	5 days	100	500
Drum Staging	16 hrs	40	640
Back hoe	5 days	200	1000
Decon Station	1	600	600
			$ 12,190 (subcontractor cost only)
Development	12 hrs	125	$1500
Devel H_2O Disposal $0.30/gal	5000 gal	0.30	$1500

Trenching & Piping

200 ft @ $3.00/LF = $600.00

PROJECT Pump & Treat Cost Estimate	COMP. BY H.F.	JOB NO.
	CHK. BY	DATE

— StartUP 2 Weeks

Week 1

(2) Engineers	40hrs	$ 20	2 mult	3200

Week 2

2 Engineers	16 hrs	$ 20	2 mult	1,280
				4,480
				≈ $4500

— Construction Management (includes well installation)

Personnel	Base (hours)	Rate	Mult	Total
Geologist	80	20	2.0	$ 3,200
Engineer	200	20	2.0	8000
Sr. Eng	50	30	2.3	3,450
P.M.	12	40	2.0	960
				15,610
				→ $15,700

PROJECT Pump & Treat Cost Est	COMP. BY H.F.	JOB NO.
	CHK. BY	DATE

Concrete Pad & Enclosure

Enclosure			$3000
Concrete Pad (6" thick)	$ 200/ft²	8' x 8'	12,800
Berm (6" high)	$20/LF	32 LF	640
			= 16,440
			⇒ $ 16,500

PROJECT Pump & Treat Cost Est.	COMP. BY	JOB NO.
	CHK. BY	DATE

Operations & Maintenance (monthly)

Personnel	Hrs	Rate	Mult	Total
Engineer	16	20	2.0	640
Geologist	16	20	2.0	640
Sr Eng	3	30	2.3	207
P. M.	1	40	2.0	80
				1567

$\Rightarrow$ \$1600

Utilities

Discharge to sanitary Sewer @ \$2.85 / 1000 gal of discharge

∴ 30 gpm 2 recovery wells for one month

$$\frac{60 \text{ gallons}}{\text{min}} \times \frac{60 \text{ min}}{1 \text{ hr}} \times \frac{24 \text{ hr}}{1 \text{ day}} \times \frac{30 \text{ day}}{1 \text{ month}} = 2{,}592{,}000 \text{ gal/month}$$

$$\frac{2{,}592{,}000}{1000} \times 2.80 = 7257.60$$

$$\approx 7275.00$$

Electric \$ .07/Kw hr (1 Hp = .746 Kw)

(2) submersible pumps @ 1.5 Hp = (2) 1.5 (.746) ≈ 2.25 Kw

(1) discharge pump @ 2 Hp = 2 (.746) ≈ 1.50 Kw

(1) Blower 5 Hp = 5 (.746) ≈ 3.75 Kw

= 7.50 Kw

Hours per month = 24 hrs × 30 days = 720 hrs

$$\frac{\$0.08}{\cancel{\text{KW}}\cdot\cancel{\text{HR}}} \cdot 7.50 \text{ KW} \cdot 720 \text{ hrs} = \$432$$

≈ 450

7275 + 450 = 7725

PROJECT Pump & Treat Cost Est	COMP. BY H.F.	JOB NO.
	CHK. BY	DATE

Site Monitoring

Analytical

SW/SD Sampling @ 4 locations (monthly)

$55/sample 8 samples = $440/month

Monitoring Wells 12 wells Bi-Monthly

6 samples monthly = $330/month

Influent/Effluent Bi monthly

2 samples monthly = 110/monthly

= 880

~ $900/month

LOE SW/SD (monthly)

	No	Hours	Rate	Mult	Total
Eng/Geo/Tech	2	10	20	2	800
Tech Lead	1	4	30	2.3	276
PM	1	1	40	2	80
					1156

LOE Monitoring Wells/Influent-Effluent

Eng/Geo/Tech	2	30	20	2	2400
TL	1	6	30	2.3	414
PM	1	2	40	2	160
					2974

~ 3000

Bimonthly

~ 1500

$25 Misc Supplies

1500 + 1156 + 25 = 2681

~ $2700

FORM 00.01 REV. 5/93

ABB Environmental Services, Inc.

IN SITU AIR SPARGING

PROJECT Air Sparging / SVE Pilot Test Cost (Both)	COMP. BY	JOB NO.
	CHK. BY	DATE

*Based on six phases of running Pilot scale Test(s)

1) Planning
2) Procurement
3) Set-Up / Installation
4) Running Tests
5) Break Down
6) Evaluate Data

Pesonnel Description	Base	Rate	Subtotal	Multiplier	Total
TOM	40	40.00	1600.00	1.90	3,040.00
Technical Expert	48	40.00	1920.00	2.25	4 320.00
Principal Engineer	240	30.00	7200.00	2.25	16,200.00
Engineer	550	20.00	11,000	1.90	20,900.00
Geologist/Scientist	550	20.00	11,000.	1.90	20,900.00
PA	40	15.00	600.00	1.90	1,140.00
CAD	32	20.00	640.00	1.90	1,216.00
WP	30	12.00	360.00	1.90	684.00
		Sub Tot /	Approximate Labor $		68,400

Travel	2 flights @ $600	1,200.00
	10 Lodging Nights @ 70	700.00
	10 per Diem @ 34	340.00
	10 Car Rental @ 50	500.00
	2 Fuel @ 20	40.00
Indirect Costs (phone, fax, shipping, copy, expendables)		3000.00
Drilling Cost		10,600
Analytical Services		1,200.00
Equipment		10,750.0
	SubTotal	27,830.0

FORM 00.01 REV. 4/81

ABB Environmental Services, Inc.

Total

PROJECT Air Sparging / SVE Pilot TEST	COMP. BY	JOB NO.
	CHK. BY	DATE

Equipment Cost for Pilot Test
* Assume (2) weeks for set up, test, and break down.

Item	Unit Cost	Total ($)
Regenerative Vacuum Blower 2 HP, single phase, 220 V, Moisture Sep, solids filter	1700/month	1700
Air Compressor 1/2 HP, single-phase, 220-V oil-less, rotary vane vac pump	3000/month	3000
Thermometers	125 ea	250
Pressure Relief Valves	30 ea	90
GENERATOR single-phase, 220V, diesel	2250/month	2250
Flow Meters	50 ea	150
Pressure Gauges	various	500
PVC Pipe	$2/ft	800
PVC Fitting, Valves, Other (Misc)	Various	1000
Tubing, Tape, Glue, Other	various	500
Steel, Brass, Other Fittings	various	500

Approx Total $ 10,740.00

≈ 10,750.00

PROJECT	COMP. BY	JOB NO.
	CHK. BY	DATE

Drilling	(2)	4" Ø Sparge Wells (1) 15' BLS / (1) 40' BLS	$2475
$45/ft 4" Ø	(6)	2" Ø observation points to 10'	1800
$30/ft 2" Ø	(6)	2" Ø observation points to 35'	6300
			10,575
			≈ 10,600

* Drilling Prices are all inclusive - (Install, Material etc)

Analytical @ $60 per sample VOC's
(no shipping)
Assume 20 vapor samples = $1200

FORM 00.01 REV. 4/81

ABB Environmental Services, Inc.

PROJECT Air Sparging / SVE INSTALLATION Cost Est.	COMP. BY H.F.	JOB NO.
	CHK. BY	DATE

— SVE Wells 16 wells @ 10' BLS $4800.00

32 (3) $30/ft (install, material, develope and completion)

— Additional Monitoring Wells ($30/ft)

8	2 @ 18' Bls	=	1,080.00
24	4 @ 40 Bls	=	4,800.00
			5,880.00
		⇒	5,900.00

— Drill Cuttings Disposal / Handling $100 / 55gal drum

				Drums
Horizontal Drilling		10 drums	=	10
SVE Wells	16 wells	2 each	=	32
Monitoring Wells				
	intermediate	4 each	=	8
	deep	7-8 each	=	28
				78 55gal dru

≈ $7800

Approx 22 yd³

Trenching & Piping

2 rows of 250' (SVE & Sparge)

300' MISC ⇒ 800 ft

@ $3/ft

= $2400

FORM 00.01 REV. 5/93

ABB Environmental Services, Inc.

TRENCHLESS SPECIALTIES

Horizontal Directional Drilling For
Infrastructure & Environmental Applications

September 27, 1996

Mr. Harlen Faircloth
ABB Environmental
1080 Woodcock Road
Suite 100
orlando, Florida 32803

Re: Directional drilling for installation of horizontal wells; Orlando, FL

Dear Mr. Faircloth:

Trenchless Specialties (TS), is pleased to provide the attached budgetary proposal, for the scope of work as described in the attached methodology plan. The following is based on information obtained in our recent telephone conversation.

We appreciate your interest in utilizing Trenchless Specialties. Please do not hesitate to call if you have any questions.

Sincerely,

Randall S. Bratcher

Randall S. Bratcher
Project Manager

PRICING

TS will mobilize, set-up, excavate the entry and exit pits, drill the boreholes, supply and install the screen, risers, and demobilize for the following prices. All prices are subject to the qualifications outlined below.

Pricing for installation of 2 wells

HW	Total Bore Length	Depth	Total Price	Per Foot
1,2	862'	14' &40'	$69,500.00	$80.62

QUALIFICATIONS

The following qualifications and other rates apply to the above price quote:

1. ***Work Stoppages*** - The above price assumes that no work stoppages caused by others are encountered from the time TS mobilizes to when we demobilize. Work stoppages caused by others will result in a standby rate charge of $300/hour with a maximum of $3000/day.

   Once actual drilling operations commence, work may (not in all cases) need to continue on a 24 hour basis until the pipe or conduit material is in the ground. If an extended work stoppage occurs (approximately 2 hours or more) during the pilot hole phase, the drill pipe may have to be removed from the hole to minimize risk of losing the pipe due to borehole collapse. This collapse would be beyond the control of TS and time spent drilling the borehole, removing the pipe and redrilling to the same point would be charged at the standby rate and no daily minimum would apply. If an extended work stoppage occurs during the pullback phase (pulling the material in the borehole) then there would be substantial risk of getting the pipe or conduit and drill tools stuck in the hole. Cost for equipment and material lost would be billed at cost and a standby rate would apply as described above.

2. ***Underground Obstructions*** - If an unknown, unmarked or improperly marked underground obstruction is encountered and TS is delayed more than 2 hours to deal with the obstruction or if abandonment and redrilling is required, standby rates would apply for the delay, removing the drill pipe, abandoning the hole and/or redrilling to the same point. No daily minimum rate would apply. Abandonment materials would be charged on a cost + 15% basis. Cost of repair, if any, of the obstruction will be the responsibility of others.

3. ***Water*** - Client will arrange for water availability on site.

4. ***Tracking of Bores*** - The wire line method of tracking the borepath(s) has been provided for in this proposal.

5. ***Permits*** - TS will obtain any necessary well construction permits. Any additional permits will be provided by client.

GEOPURE CONTINENTAL
SYSTEMS & SERVICES

MID-ATLANTIC OFFICE
3219 NORTHSIDE DRIVE
RALEIGH, NC 27615
(800) 257-7139 • FAX (919) 878-3235

March 20, 1995

Harlan Faircloth
ABBEnvironmental
1400 Centerpoint Blvd
Knoxville, TN 37932-1968

Proposal # MA 1030
Terms: Net 30
Price: Firm 60 Days
Delivery: 8 Weeks
FOB: Gainesville,FL

Project: [redacted]
Location: [redacted]
Design Flow Rate: [redacted]
Scope: XP Skid mounted Groundwater Treatment System

PROPOSED TREATMENT SYSTEM

(6) **EVACUATOR II TR-102 TOP & BOTTOM LOADING PUMPS** **$ 13,932.00**
INCLUDES:
- (50') Down Well Hoses and Quick Disconnect Fittings/Well
- (6) 4" Well Clinchers
- (6) .01 Micron Filter Regulators

(1) **ACPA5XP COMPRESSOR PACKAGE (5 HP)** **$ 9,805.00**
INCLUDES:
- Belt Guard
- 60 Gallon ASME Tank
- Automatic Tank Drain Valve
- ASME Safety Valve
- Service Valve
- Pressure Gauge
- Inlet Filter
- Magnetic Motor Starter
- 5 HP/ 230 Volt/ Single Phase XP Motor
- Filter/Regulator
- XP Refrigerated Air Dryer R-20

(1) **DP-8 HYDRO FLO OIL WATER SEPARATOR** **$ 7,418.00**
INCLUDES:
- 1-25 GPM FRP Oil Water Separator Mounted on a Painted Steel Stand
- 270 Gallon Double Walled Product Recovery Tank (Lube Cube)
- Product Storage High Level Switch/ Alarm Shut-Off

(1) **1-20 GPM XP REPRESSURE SYSTEM** **$ 2,560.00**
INCLUDES:
- 100 Gallon Surge Tank with Bulk Head Fittings
- Intrinsically Safe Level Controls Low/ High/ High-High
- Myers Model 100M1XP Repressure Pump (1.0 HP/ XP)

GEOPURE CONTINENTAL
SYSTEMS & SERVICES

[redacted]

(1) **20HPBAG2L BAG TYPE PREFILTER SYSTEM** **$ 1,500.00**
INCLUDES:
25 Micron Ametek Bag Filter
Qucik Disconnect Fittings
Pre/Post Pressure Gauges
Pre/Post Sample Ports

(4) **HPL-200 HIGH PRESSURE GAC DRUMS** **$ 3,980.00**
•200# Virgin 950 Iodine GAC/ea
•75 PSI Pressure Rated Epoxy Coated Drum
•1" Inlet and Outlet
•Exchange service available (see spent carbon return policy)

(1) **MASTER METER 1" TOTALIZING METER** **$ 280.00**
1-20 GPM Totalizing Meter

(1) **UL APPROVED MAIN SYSTEM CONTROL PANEL** **$ 425.00**
IDEC PLC Controller in a Nema-4 enclosure
will integrate all above equipment with high level interlock
and automatic restart. Externally mounted with locking blank front plate.
•Note: Each line item includes control pricing
•To be installed in a non hazardous area by client

(1) **20SVE70 SOIL VACUUM EXTRACTION SYSTEM** **$ 5,715.00**
INCLUDES:
•Roots Blower URAI-22
•XP Motor 1.5 HP/ Single Phase/ 230 Volt
•Stoddard D13-1.5 Intake and Discharge Silencer
•55 Gallon Moisture Knockout with High Level Switch
•Solberg CSL-849-150HC Inline Particle Filter
•Pressure Relief Valve
•Vacuum Gauge
•Temperature Gauge
•NEMA-4 Controls
•Bleed Valve and Silencer
•Mounted on Steel Skid
•Influent/Effluent Sample Ports

(1) **10'x12' GEOPURE PAINTED STEEL SYSTEM SKID$ 1,000.00**

PROJECT Air Sparging / SVE Installation Cost Est.	COMP. BY	JOB NO.
	CHK. BY	DATE

— Startup & Optimization

Personnel	Base	Rate	Mult	Total
Engineer	80	20	2.0	3,200.00
Geo/Scientist	24	20	2.0	960.00
Senior Eng	20	30	2.3	1,380.00
PM	4	40	2.0	1,280.00
				= 6820.00

≈ 200 misc.

⟹ $7000

— Construction Manag.

Engineer	200	20	2.0	8,000.00
Geologist	120	20	2.0	4,800.00
Senior Eng	52	30	2.3	3,588.00
PM	20	40	2.0	1,600.00
				17,988.00

Misc Expenses ≈ 500

∴ $18,500.00

60K
70K

PROJECT Air Sparging / SVE Installation Cost Estimate	COMP. BY H.F.	JOB NO.
	CHK. BY	DATE

Operations & Maintenance (Monthly)

Personnel	Base	Rate	Mult	Total $
Engineer	16	20	2.0	640
Geologist	16	20	2.0	640
Senior Eng	2	30	2.3	138
PM	2	40	2.0	160
				1575
				≈$1600

Utilities (Electric Only)

(2) 1.5 Hp ~ 2.25 KW

1 5 Hp ~ 3.75 KW

6.00 KW

@ $0.08/kwhr $\frac{.08}{KW \cdot Hr} \cdot 6.0\,KW \cdot \frac{24\,hr}{1\,day} \cdot \frac{30\,day}{1\,month} = \$345.60$

Assume $400 Total Utilities

- Assume $50.00 in Misc Supplies for O & M

PROJECT Air Sparging / SVE Install Cost Est.	COMP. BY	JOB NO.
	CHK. BY	DATE

Site Monitoring

Monthly SW/SD Sampling @ 4 location
$55 / sample 8 samples $440/month

Monitoring Well sampling (Bi Monthly) 12 wells
6 well/month @$55/sample 330/month

Vapor Effluent Samples (monthly) 5 locations
@ $ 60/sample 300/month

⇒ $1070/month

LOE

Personnel	Base	Rate	Mult	Total
Engineer	30	20	2.0	1,200
Geologist	20	20	2.0	800
Senior Eng	10	30	2.3	690
PM	5	40	2.0	400
				3,090

≈ 3,100